VOL. XXIV. — No. 7. JULY 1947

Monthly Bulletin of the International Railway Congress Association

(English Edition)

Digitized by the Internet Archive
in 2024

https://archive.org/details/rail-international_1947-07_24_7

Suitable for

International Traffic on the Continent of Europe

The WESTINGHOUSE

Automatic Brake Type Lu.

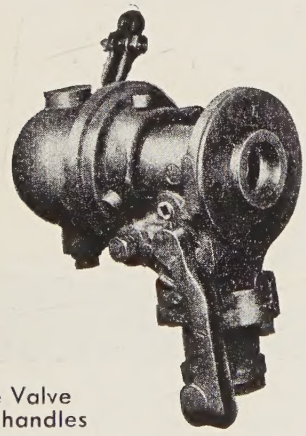
THE LIBRARY OF THE
JAN 15 1952
UNIVERSITY OF ILLINOIS

provides the selective functions

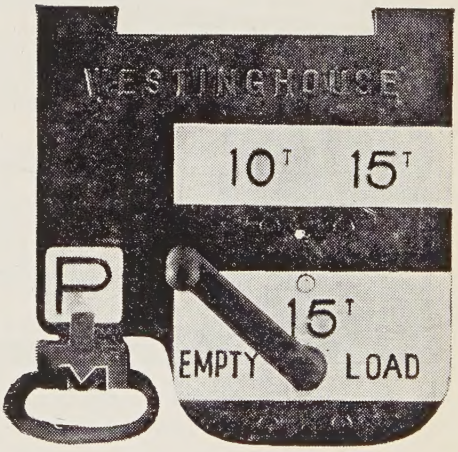
EMPTY or LOAD	PASSENGER or FREIGHT	PLAIN or MOUNTAIN

by means of a combination of the

WESTINGHOUSE Lu. TRIPLE VALVE and CHANGE-OVER GEAR



Lu Triple Valve showing handles controlling Passenger-Freight and Plain-Mountain operation.



Change-over gear plate, showing handles controlling Plain-Mountain and Empty-Load operation.

This brake system conforms in every respect with the 33 conditions laid down by U. I. C. (L'Union Internationale des Chemins de Fer), and has been approved by them as suitable for international traffic on the Continent of Europe.

Westinghouse Brake & Signal Co. Ltd.
82, York Way, Kings Cross
London N. 1. England

•

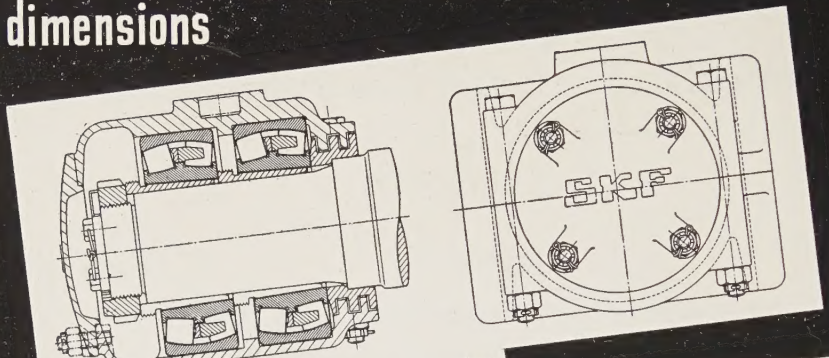
Saxby & Farmer (India) Ltd.
Entally
Calcutta

•

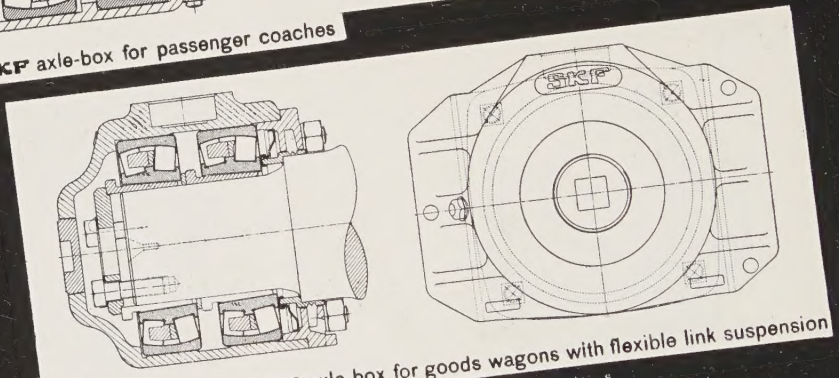
Westinghouse Brake
(Australasia) Pty. Ltd.
Concord West, N.S.W.

THE SKF RAILWAY AXLE-BOX

containing two self-aligning roller-bearings can carry a heavier load than any other type of comparable dimensions



Standard SKF axle-box for passenger coaches

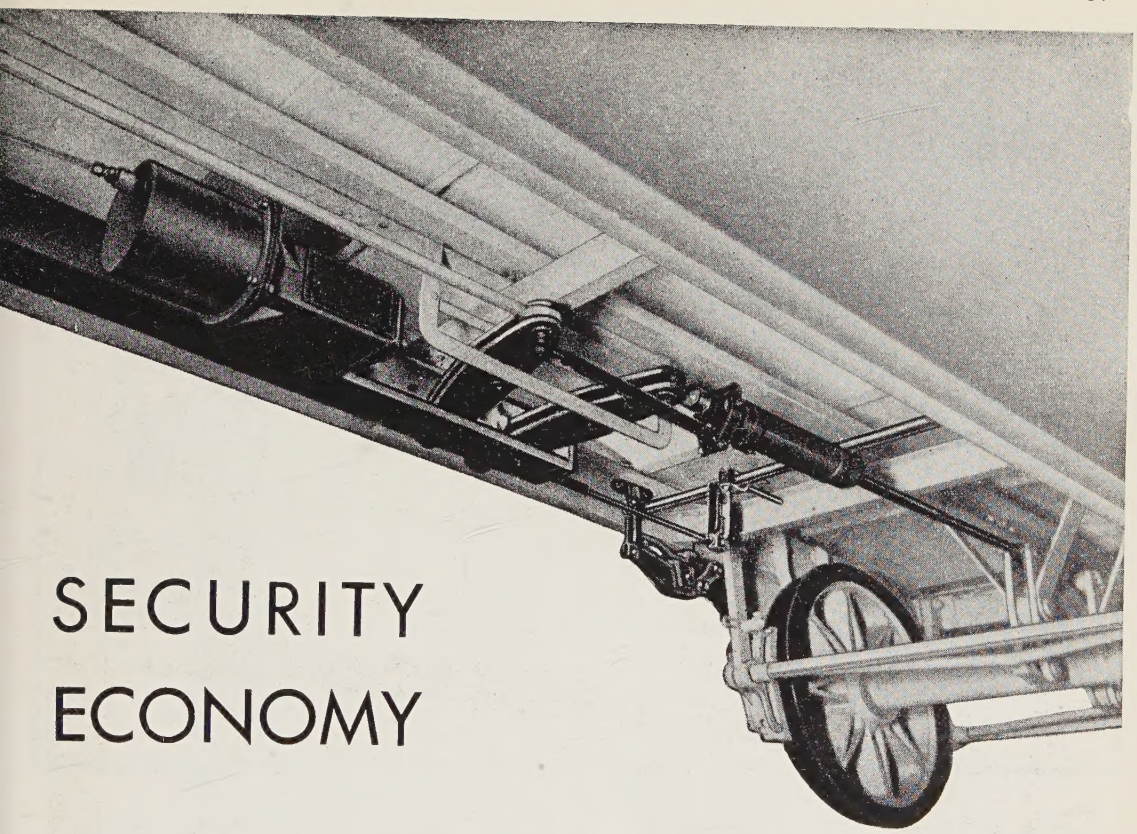


Standard SKF axle-box for goods wagons with flexible link suspension

- SKF self-aligning roller-bearings adapt themselves instantaneously to all misalignment, and combine great radial and axial carrying capacity with low friction
- Thanks to the tapered sleeves, the axle journals suffer no wear or damage in the mounting or dismantling.
- The journals are cylindrical and therefore easy to machine.
- The SKF bearing components are readily separated and reassembled - a valuable aid to inspection and cleaning.

SKF

SOCIÉTÉ BELGE DES ROULEMENTS A BILLES
SOCIÉTÉ ANONYME
117, BOULEVARD ANSPACH BRUXELLES Téléphone : 11.65.12-13-14-15



SECURITY
ECONOMY

SAB

BRAKE REGULATOR TYPE DR

with double rapid action

CONTINUOUS LOAD BRAKE ADAPTER TYPE AC

for braking power proportional to the load

SVENSKA AKTIEBOLAGET BROMSREGULATOR

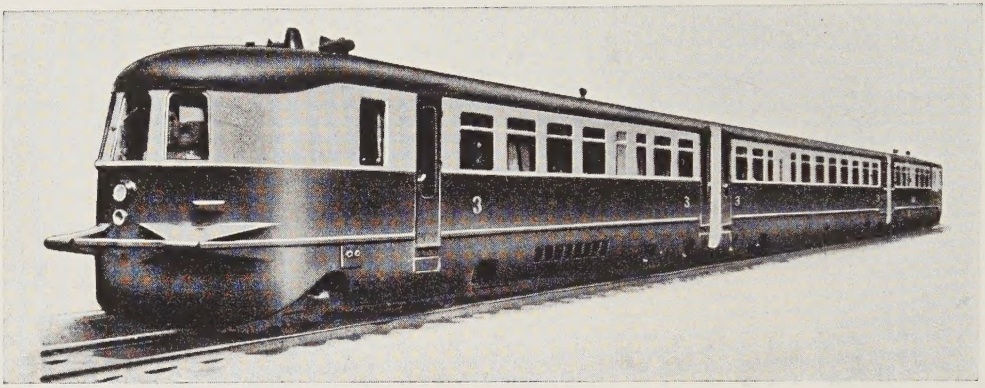
Adelgatan 5, Malmö, Sweden

STÉ ANGLO-FRANCO-BELGE

DES ATELIERS DE LA CROYERE, SENEFFE ET GODARVILLE

Head Office : LA CROYÈRE (BELGIUM)

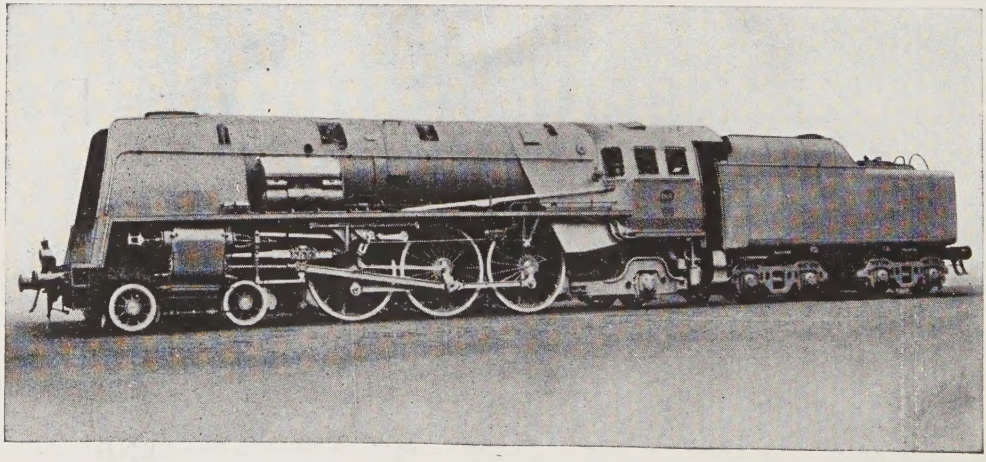
Telegrams : LOCOMORAM-LA CROYÈRE Telephone. 2 lines : LA LOUVIÈRE Nos. 44 and 1229



Carriages of every class and description. — Railcars, steam, electric, diesel oil locomotives. — Ordinary and special waggons. — Caboose cars and brake vans. — Tenders. — Crossings, switches and track material. — Boiler and plate work. — Forgings. — Heavy flanging.

JOHN COCKERILL S. A.

SERAING (Belgium)



METALLURGY

MACHINERY and METAL STRUCTURES

SHIPYARD AT HOBOKEN (ANTWERP)

A Moussiaux
Safety
BELGIAN NATIONAL RAILWAYS

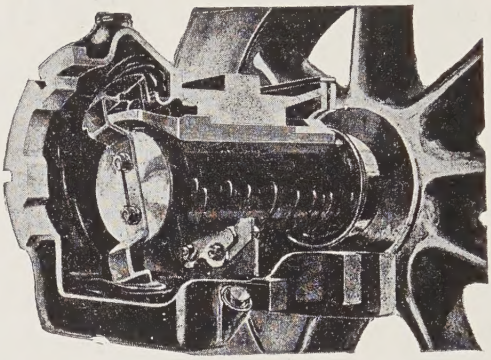
«ISOTHERMOS»

Axle box with mechanical lubrication

Bearing " Athermos "

Complete safety with any loads and at the highest speeds

•



Oil saving

No maintenance

Minimum coefficient of friction

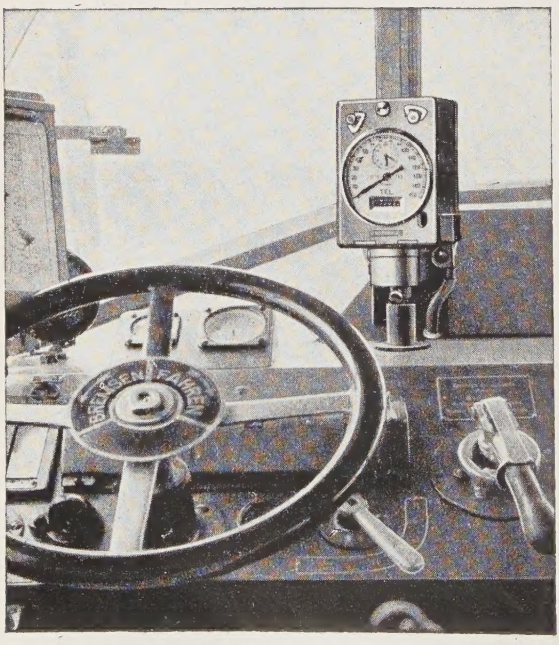
•

Brussels - Société Générale " Isothermos " - Paris

9, rue du Moniteur **35, rue de la Tour d'Auvergne**

Agents or Representatives in all main countries

In Great Britain : J. STONE & Co. Ltd. Oceanic House - 1a, Cockspur Street, London S.W.1



The TELOC Speed Indicators and Recorders

are the product of experience since 1887 in the construction of speed indicators and recorders for railway locomotives and vehicles.

The new type TELOC indicates the speed, the total distance travelled, the time of day. It records on the chart the speed, distance travelled, the time in hours and minutes and the time and duration of stops. If required the instruments can also be fitted with apparatus to record the pressure in the brake pipes, the direction of travel and the passing of signals, etc.

Hasler S.A. Berne

MANUFACTURE D'APPAREILS TÉLÉPHONIQUES ET DE PRÉCISION

FONDÉE EN 1852 TÉLÉPHONE NO. 64

S. A. LA BRUGEOISE et NICAISE & DELCUVE

Steel-works, Forges and Engineering Works

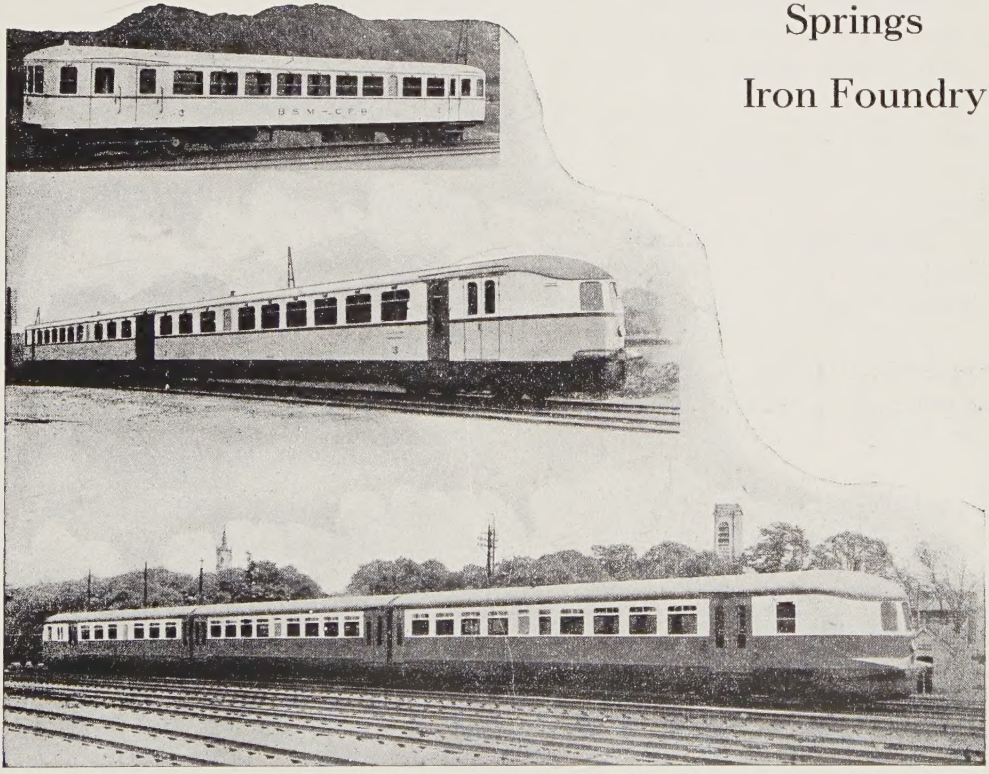
Works at St-Michel near Bruges and at La Louvière (Belgium)
General Management at St-Michel near Bruges

Rolling Stock and Fixed Equipment for Railways and Tramways

Bridges, Frames, Tanks
and all Metallic Constructions riveted and welded
Steel Castings of all kinds and qualities

Springs

Iron Foundry



Alphabetical Index of Advertisers

Firms :		Specialities :
Anglo-Franco-Belge des Ateliers de La Croyère, Seneffe et Godarville (Soc.) .	V	Locomotives and Railway rolling stock.
Ateliers des Charmilles (S. A.)	—	Air brakes for railways and tramways.
Ateliers de Construction Oerlikon . . .	—	Electrical equipment for all traction requirements.
Belgian National Railways	VI	Safety.
Brown, Boveri & C°. Ltd.	—	Electric locomotives.
Brugeoise et Nicaise & Delcuve	VIII	Railway rolling stock and fixed equipment
Cockerill (John)	V	Machinery and metal structures.
Claude-Paz & Silva	—	Fluorescent tubes and lamps.
Eclairage des Véhicules sur Rail (L') .	—	Electrical equipment.
English Electric Company, Ltd (The) .	—	Railway electrification
Firth (Thos) & Brown (John), Ltd. . .	—	Railway forgings and tools.
Hasler (A. G.)	VII	Speed indicators and recorders.
Isothermos (Société générale)	VII	Axleboxes.
S. A. B. (Svenska Aktiebolaget Broms-regulator)	IV	Automatic slack-adjusters.
S. K. F. (Société Belge des Roulements à Billes)	III	Axleboxes.
Usines Emile Henricot	—	Automatic couplers; steel castings for railway rolling stock.
Vi-Spring Products Ltd.		Cushions and seating.
Westinghouse Brake & Signal C° Ltd. .	II	Railway signaling. Brakes.

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU SITE, BRUSSELS.

Yearly subscription for 1947 : { **Belgium . . . . . 700 Belgian Francs** / **Universal Postal Union . 800 Belgian Francs**

Price of this single copy : 80 Belgian Francs. (not including postage)

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau Site, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

Advertisements : All communications should be addressed to the Association, **19, rue du Beau Site, Brussels.**

CONTENTS OF THE NUMBER FOR JULY 1947.

CONTENTS	Page.
I. **Light railcars for colonial railways,** by J. L. Koffman	655
II. **Safe stresses in axles.** Determination of axle shape and dimensions, by M. Kammerer	674
III. **Tickets,** by Lionel Wiener. — *Part E :* Ticket representation of tariffs. Special tickets. *(Concluded.)*	685
IV. Large **concrete building takes a trip**	705
V. New Books and Publications :	
Traité d'exploitation des transports *(Treatise on the organisation of transport),* by P. De Groote	711
The **locomotives of Sir Nigel Gresley,** by O. S. Nock	714
VI. Monthly Bibliography of Railways	49

LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association.

READING ROOM : **19, rue du Beau Site, Brussels.**

Works in connection with railway matters, which are presented to the Permanent Commission, are mentioned in the « Bulletin ». They are filed and placed in the library. If the Executive Committee deems it advisable they are made the subject of a special notice. Books and publications placed in the reading room may be consulted by any person in possession of an introduction delivered by a member of the Association. Books, etc., may not be taken away except by special permission of the Executive Committee.

The Permanent Commission of the Association is not responsible for the opinions expressed in the articles published in the Bulletin.

All original articles and papers published in the Bulletin are copyright, except with the consent of the Authors and the Committee.

An edition in French is also published.

VOL. XXIV. — No. 7. July 1947.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .431 .72 & 625 .616]

Light railcars for colonial railways,

by J. L. KOFFMAN,

Dipl.-Ing., M. S. A. E., A. M. I. Loco. E.

The commodity sold by a railway is transportation: safe, comfortable, rapid and cheap. Starting from humble beginnings the first three items improved very considerably indeed, but due to certain trends of development the price of the commodity offered did not improve — on the contrary very substantial increases had often to be faced by the public. The reasons for this trend are well known and need not be dealt further here, but so far as the subject of this article is concerned it should be mentioned that the quest for safety and comfort at gradually increasing speeds has lead to the development and use of very heavy rolling stock, ultimately resulting in a payload/dead weight ratio of not less than 1:48 with some pre-war crack trains such as the « Rheingold » express, and this to a considerable extent affects the operating costs.

It appears that the reason for this was the desire for greater safety — which (all other things being equal) is inversely proportional to $\frac{mv^2}{2}$, and yet both m and v were increased simultaneously — and comfort. The latter naturally leads to roomier carriages the weight of which also increased, last not least because of the so often expressed belief that heavier cars ride better than light ones, and the consequent reluctance to reduce weight. This belief — based on experience with light vehicles fitted with mostly inadequate spring systems — was often accepted on face value instead of investigating in greater detail the effect of vibrations on the human body which after all constitutes the fundamental problem of comfort in railway transportation.

In the following the writer will show how the problem has been solved for two types of light railcars one of which whilst designed before the war has been completed only a few months ago. The vehicles built to the specification of the Crown Agents for the Colonies incorporate several novel features some of which, it is understood, have also been adopted as standard about 1942 by the German State Railways for their fast and express rolling stock. (1)

(1) Numbers in parantheses refer to the Bibliography at the end of the article.

A new car should usually meet the requirements for « *good riding qualities* », but it is not often that the meaning of « good riding qualities » is elucidated; mostly because it is a somewhat nebulous magnitude for all concerned. It is however agreed that generally the design of a vehicle should be such that the effect of forces during the motion should be as small as possible, i.e. they should not be felt as disturbing shocks or changing accelerations or jerks. If this cannot be accomplished by the general design, separate devices must be incorporated which so convert the jerks that they are no longer felt by the passengers as uncomfortable.

The general aim of designers is — so far as vertical vibrations are concerned — to ensure a natural frequency of the suspension in the region of 90 to 100 cycles per min. i.e. a static deflection of about 3.5 inches, due allowance being made in the design for the payload not to result in a deflection in excess of the loading gauge and/or buffer height limitations. Numerous suspension designs were developed with the view of reducing vibrations but almost nothing was known as to just which type of vibrations it was which affected the passengers i.e. the physiological aspect — the crux — of the matter. It was only comparatively recently that exhaustive tests were carried out to obtain relevant data (2). The main results are shown in *Fig. 1*. The regions shown here may be defined on the following basis :

Annoying or disturbing — the passenger notes that certain organs or parts of his body (for example head) have greater vibration than he himself, and he tries to prevent this by tightening up on certain muscles.

Very uncomfortable, painful or unbearable — the passenger wants very little of the treatment to feel uncomfortable.

The data obtained by Meister for standing and reclining passengers indicate that

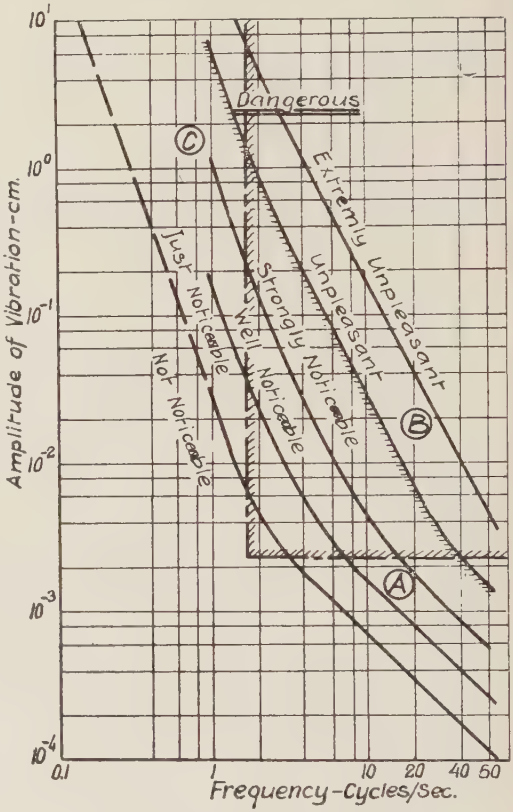


Fig. 1. — Vibration sensitivity of standing and reclining passengers.

the human body is affected not so much by the amplitude or frequency of the vibration but by the acceleration within the wide region — which covers most car suspensions — marked « B » in Fig. 1, whilst within region « A » it is the velocity of vibration $v = 2\pi fa$ (f = frequency, a = amplitude) that matters. In the region « C » of slow frequencies and large amplitudes the change of accelera-

tion $\left(\frac{dv}{dt^3}\right)$ or shock is the deciding factor. The vibration characteristic of a « comfortable » car should not exceed the line marked « strongly noticeable » so far as standing and reclining passengers are concerned. Sitting passengers are somewhat less sensitive. Meister's researches cover a relatively wide field and a close study of his findings is recommended to every designer of passenger carrying vehicles.

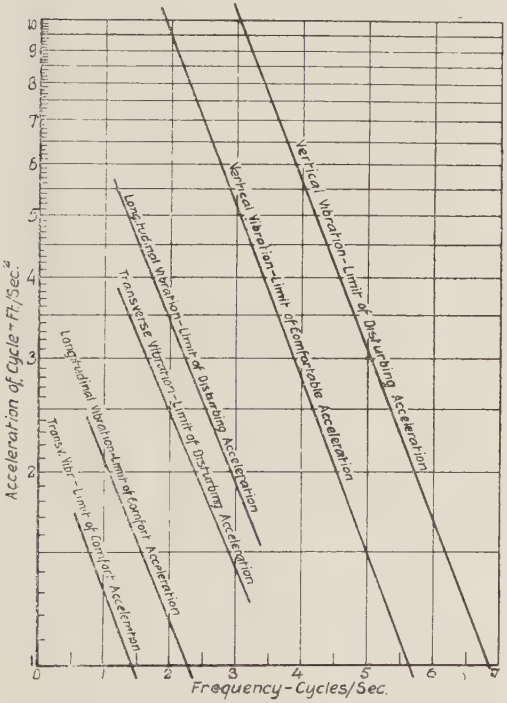

Acceleration of Cycle - Ft./Sec.²
Frequency - Cycles/Sec.
Vertical Vibration-Limit of Disturbing Acceleration
Vertical Vibration-Limit of Comfortable Acceleration
Longitudinal Vibration-Limit of Disturbing Acceleration
Transverse Vibration-Limit of Disturbing Acceleration
Longitudinal Vibration-Limit of Comfort Acceleration
Transv. Vibr.-Limit of Comfort Acceleration

Fig. 2. — Vibration sensitivity of passengers seated on unpadded seats.

Somewhat similar investigations were carried out by Zeller (3) and also at Purdue University (4). The main results of the latter tests carried out with passengers seated on hard unupholstered seats are shown in *Fig. 2* and these can be represented reasonably well by the equation,

$$C = Ae^{0.6f} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where :

C = A constant called comfort index;
A = Maximum acceleration in ft./sec²;
e = Basis of natural logarithm (2.7183);
f = Frequency of vibration in cycles/sec.

A finding of interest is that in the standing position the human body is most sensitive to vertical vibrations, while in reclining position, horizontal vibrations at right angles to the body axis produce stronger sensations than those parallel to the body axis. The limits found were as follows :

Feeling.	*Direction.*	*Maximum « C ».*
Uncomfortable	Vertical	$C_V = 64.7$
Disturbing	Vertical	$C_V = 31.2$
Uncomfortable	Longitudinal	$C_L = 11.73$
Disturbing	Longitudinal	$C_L = 4.02$
Uncomfortable	Transverse	$C_T = 8.21$
Disturbing	Transverse	$C_T = 2.35$

It is a matter of common observation, confirmed by tests, that a passenger sitting on a well-upholstered seat can withstand greater vibrations of his body than if he sits on the hard seat. A « comfortable » seat does two things. It reduces the vibration transmitted from the vehicle to the passenger and it also increases the amount of vibration which he can withstand comfortably, probably because his weight is better distributed over a larger area and is thus also receiving support from various angles, so that different nerves and muscles are affected by impressed vibrations. In addition the seat cushion grips the clothing and vice versa. Tests carried out at Purdue with upholstered seats have shown that

the relations between maximum acceleration, frequency and comfort could be reduced approximately to the following values :

Feeling.	*Direction.*	*Maximum « C ».*
Uncomfortable	Vertical	$C_V = 10 = Ae^{0.13f}$
Disturbing	Vertical	$C_V = 8.5 = Ae^{0.13f}$
Uncomfortable	Longitudinal	$C_L = 5.5 = Ae^{0.087f}$
Disturbing	Longitudinal	$C_L = 4 = Ae^{0.087f}$
Uncomfortable	Transverse	$C_T = A = 3.25$
Disturbing	Transverse	$C_T = A = 2.75$

It will be noted that the values of *Figs. 1* and *2* coincide fairly well over a wide region, whilst the curves in *Fig. 2*, as well as the limits stated above, clearly show that passengers are more sensitive to horizontal than to vertical vibration. The reason for this is probably due to the relatively greater movement of the head against the body in the case of horizontal vibration.

When dealing with both vertical and horizontal vibration the maximum « C » value is given by the vector sum C^c of the forces :

$$C_c = \sqrt{C_V^2 + C_L^2 + C_T^2} \quad . \quad . \quad . \quad (2)$$

Somewhat more recent tests carried out by Helbrig and Sperling (5) on persons seated on hard seats resembling Continental 3rd class seats have shown a similar tendency so far as sensitivity is concerned (*Figs. 3* and *4*). The « sensitivity » E, which is tantamount to « riding comfort » can be expressed by the equation :

$$E = 3.1 \sqrt[10]{a^3 f^5} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where :

f = Frequency (cycles/sec.);

a = Amplitude of vibration (mm.).

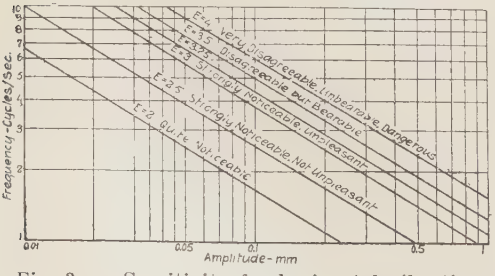


Fig. 3. — Sensitivity for horizontal vibration, passengers on unpadded seats.

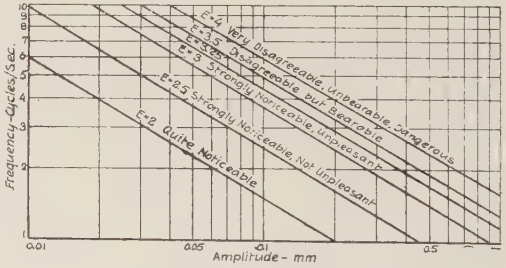


Fig. 4. — Sensitivity for vertical vibration, passengers on unpadded seats.

Vibrations not exceeding the value of E = 2.5 are well pronounced but not unpleasant and are bearable whilst those exceeding E = 4 are extremely disagreeable, unbearable, and, if extended over a longer period, dangerous to health.

A comparison of the values of *Figs. 3* and *4* shows that equation (3) applies equally well for both vertical and horizontal vibrations; the sensitivity being proportional to the factor $C = af^{5/3}$ whereas according to Purdue tests the

sensitivity is proportional to acceleration, i.e. to $(2\pi f)^2 a$.

The above data thus indicates the general direction to be taken by the designer to lead to the design of a vehicle with « good riding qualities ».

The results of investigations mentioned above do not however apply exactly to actual conditions in a vehicle due to the following reasons :

The tests on vibrating platforms are made amid stationary surroundings whilst in practice passenger and vehicle move together so that the passenger is offered an ever-changing panorama which may well divert his attention from the effects of vibration. In addition a different perspective is afforded which may minimise the motion of distant objects. Different sounds encountered in a moving vehicle may reduce the sensitivity exhibited to vibration under monotonous laboratory conditions which will of course not result in the feeling of exhilaration often experienced in a fast moving vehicle. A more comfortable position may be assumed in a vehicle seat and, last but not least, consideration must be given to the fact that the actual motions of a vehicle are not purely repetitive this breaking the monotony to such an extent that single impulses will not produce a feeling of discomfort to their intensity.

If it were possible for the wheel flanges to remain in contact with the rails, and if wheels, axles and track were perfectly rigid, then there would be no problem of lateral oscillation or hunting. Due to practical requirements, however, some clearance, is always left between flange and rail. Because of this clearance, and to a certain extent also because the axles are not rigidly constrained in the bogie frame, the movement of wheels and axles along the track takes the form of a series of successive contacts between flange and rail. If this movement occurred on a perfect track and was solely due to the coning of the tyres, the path followed by the wheels would be a sine curve the wave length of which would theoretically remain constant irrespective of speed, but depending upon gauge, wheel radius and the conicity of the tyres. The trajectory of the centre of gravity C of a wheel set which due to some interference, has been displaced sideways out of its central position, will, under ideal condi-

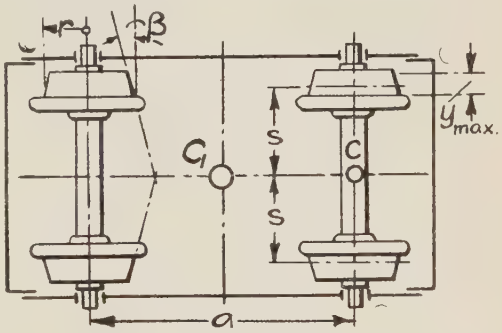


Fig. 5. — Scheme of bogie.

tions, follow the path of a sine curve of fortuitious amplitude and a wave length given by equation (4). (See also *Fig. 5.*)

$$l = 2\pi\sqrt{\frac{\tan\beta}{r.s}} \quad . \quad . \quad (4)$$

the corresponding frequency f of the resultant oscillation being given by equation (5)

$$f = \frac{V}{2\pi}\sqrt{\frac{\tan\beta}{r.s}} \quad . \quad . \quad . \quad (5)$$

whilst (6) is the equation of the sine path pursued by C

$$y = y_{max} \cdot \sin\left(X\sqrt{\frac{\tan\beta}{r.s}} \right) \quad . \quad . \quad . \quad (6)$$

where $y_{max.}$ = Max. possible clearance between wheel flange and rail (ft).

X = Point along path of C (ft);

β = Coning angle of tyres (degrees);

r = Wheel radius (ft);

$2s$ = the distance between rolling circles (ft);

v = Velocity of C i.e. vehicle speed (ft./sec.).

The transverse velocity of C will be obtained as the first derivative of equation (6)

$$V_y = y_{max.} V. \sqrt{\frac{\tan\beta}{r.s}}. \cos\left(X\sqrt{\frac{\tan\beta}{r.s}}\right). \quad (7)$$

where $V_y = dx/dt$.

The transverse acceleration will be

$$b_y = v^2 y \frac{\tan\beta}{r.s} = \frac{V^2}{R} \quad . \quad . \quad (8)$$

where R = Radius of the sine curve (ft) whilst the transverse change of acceleration or jerk will be

$$s_y = v^3 y_{max.} \left(\frac{\tan\beta}{r.s}\right)^{3/2} \cos\left(X\sqrt{\frac{\tan\beta}{r.s}}\right). \quad (9)$$

The above equations show that low values of f, v_y, b_y, and s_y can be ensured by a low value of y_{max}, but here limits are set due to obvious reasons. But it is possible to obtain a high value of comfort index and low values of f, v_y, b_y, and s_y by a low value of β and increase values of r (s being of course fixed). The vehicle speed is of course of utmost importance, but this is usually predetermined and since r is also fixed by design and operating considerations a reduction of β is the only remaining line of attack — so far as an isolated wheel set is concerned. The importance of β upon the running of standard and metre gauge wheel sets of 26 and 30 inches diameter is indicated by *Figs. 6* and 7 respectively.

The transverse displacement y_{max} can be as high as 3/16 in. without the flange running up against the rail and it is for

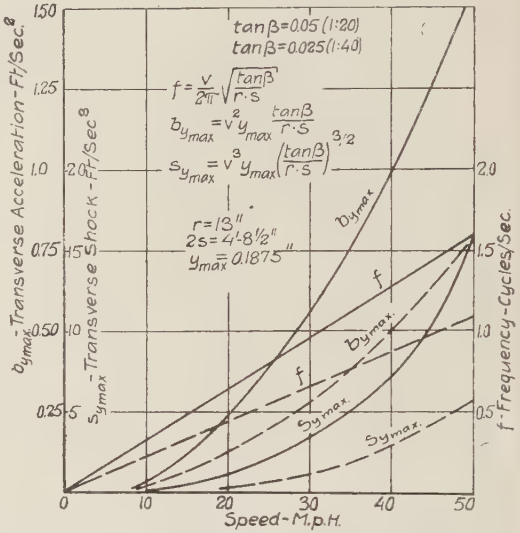


Fig. 6. — Frequency, transverse acceleration and shock — standard gauge.

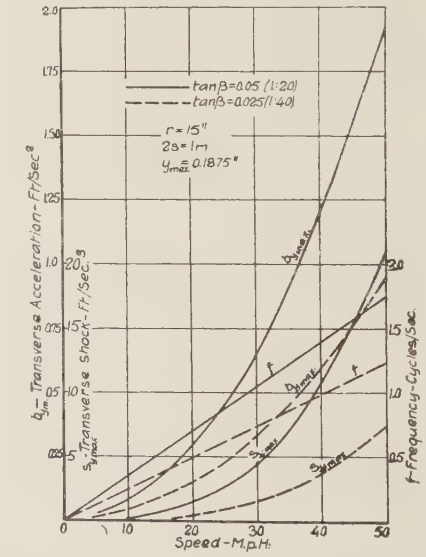


Fig. 7. — Frequency, transverse acceleration and shock — metre gauge.

this value that the above curves were calculated.

It will be noted from equation (4) that theoretically l is not affected by the speed. In actual practice this is not quite so, for as tests on the Rheingold express have shown (6) l increases with speed (in this particular case from 55.5 ft. at 3 m.p.h. to 65 ft. at 62.5 m.p.h.) due to the gyroscopic action of the revolving wheels which oppose the turning, thus causing slip and an increase of l.

According to analysis by Heumann (7) the requirements which must be fulfilled to ensure the condition of « unrestrained » running of a wheel set are usually small and may be easily met by the axlebox — hornblock clearances encountered in standard bogie frames. The axle oscillations will to a certain extent be transmitted to the bolster but since here we are merely interested in the possibility of improving — relatively — the running qualities of the vehicle this aspect of the problem will not be pursued further.

Several investigators (8) have dealt with the problem of the running qualities of bogies with axles located exactly parallel to each other without any longitudinal or transverse play whatsoever. Such conditions can be only approximately maintained in actual service but here again the theoretical deductions serve to indicate the way to improved running characteristics. According to Heumann for a bogie with both axles equally loaded and all wheels the same size the path of the centre C, follows a sine curve the wave length of which is

$$l_1 = 2\pi\sqrt{\frac{r.s}{\tan\beta}}.E \quad . \quad . \quad (10)$$

where E = Elongation Factor

i.e. such a rigid wheelbase moves like a single axle but with a longer periodic distance

$$E = \sqrt{\left[1+\frac{a^2}{4(s^2-b^2)}\right]\cdot\frac{1}{1-\frac{\tan\beta}{r.s}(s^2-b^2)}} \quad (10a)$$

where a = Bogie wheel base (ft).

The factor b can be expressed for

a = 6.5 to 16.5 ft. as

$b = 0.065\ (a + s).r.f$

f = slip friction coefficient.

For slip at right angles to the plane of the wheel $f = 0.2$ approximately.

The above equation has been deduced on the basis of the usual theory which — contrary to the « creeping » or « pseudo-glissement » theory — assumes that f is not dependent upon the velocity of slip.

A similar equation derived by Cain (9) reads

$$l_1^1 = 2\pi\sqrt{\frac{[(a/2)^2 + s^2].r}{s.\tan\beta}} \quad . \quad . \quad (11)$$

These equations apply to bogies with equally loaded non-driving axles. Heumann has investigated the running of bogies with unequally loaded axles (10) as well as those of driving bogies (11), but since for the purpose of present consideration the simple case of equally loaded trailing axles is sufficient, the reader is referred to the original articles for additional information.

Having thus shown that the riding qualities of a bogie can be improved by locating the axle exactly parallel and eliminating any play, the question now arises as to a satisfactory way of achieving this. As pointed out by the late T.H. Sanders (12) and the writer (13) a number of railways and tramways (14) have adopted bogies of different designs to a certain extent meeting the above requirements.

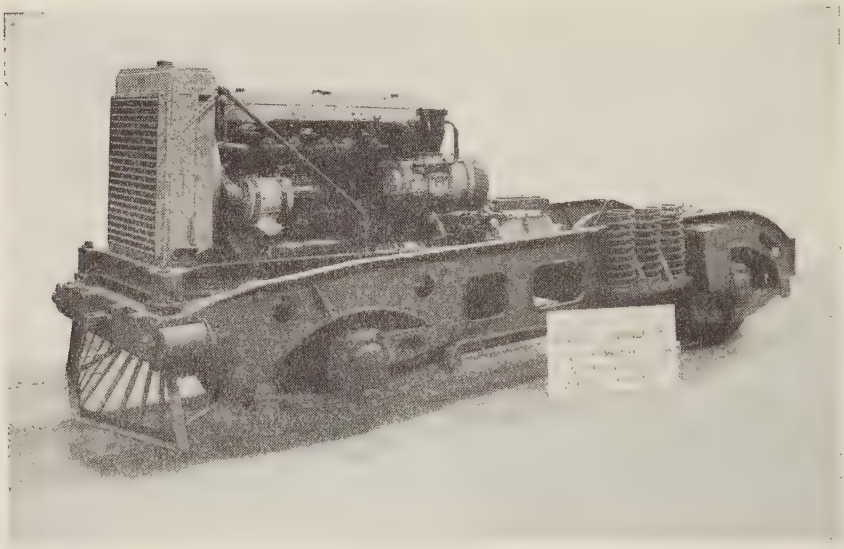


Fig. 8. — K.U.R. car power bogie.

With the bogies of the cars dealt with here the usual hornblocks have been eliminated, *Figs. 8, 9, 10* and *11*. The axles are carried in self-alighting roller bearings and the axleboxes are located in the bogie frame by means of radius arms secured via Silentbloc bushes which allow a small radial and longitudinal displacement. The bogie frame is carried on halfelliptic springs secured to the axleboxes by trunnions. *(Fig. 12.)*

Originally the top spring leaves were provided with pads shaped to ensure a variable deflection. However, as with the greatly varying loads and consequent angle variations between spring ends and the bogie frame it was difficult to secure the pads without considerably weakening the leaf ends, the pads were abandoned in favour of suitably shaped top leaves, rubbing against steel plates secured to the bogie frame. The spring ends are guided by 4-in. long clips.

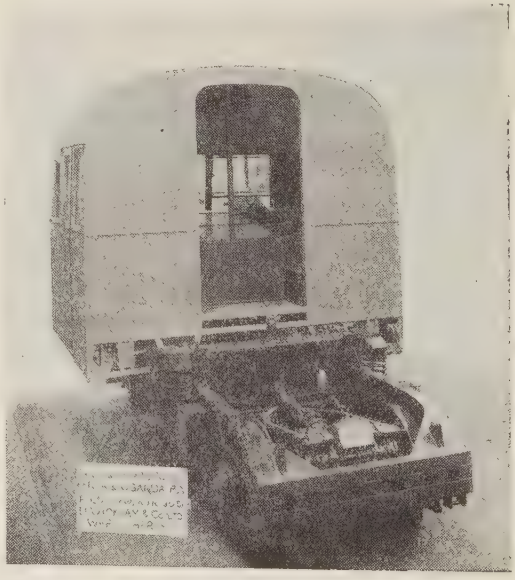


Fig. 9. — K.U.R. power bogie with cab in position.

The advantages secured by this design are as follows :

1) Better riding qualities due to axles positively secured to the bogie frame.

2) Frame and springs in line with axle box. This reduces bending stresses in axle and consequently permits a reduction of axle diameter.

3) The absence of hornblocks permits the elimination of right-angle cuts on bogie frame and thus reduces stress concentration (for the effect of these on stress concentration see Ref. [15]).

Fig. 10. — J.G.R. car power bogie.

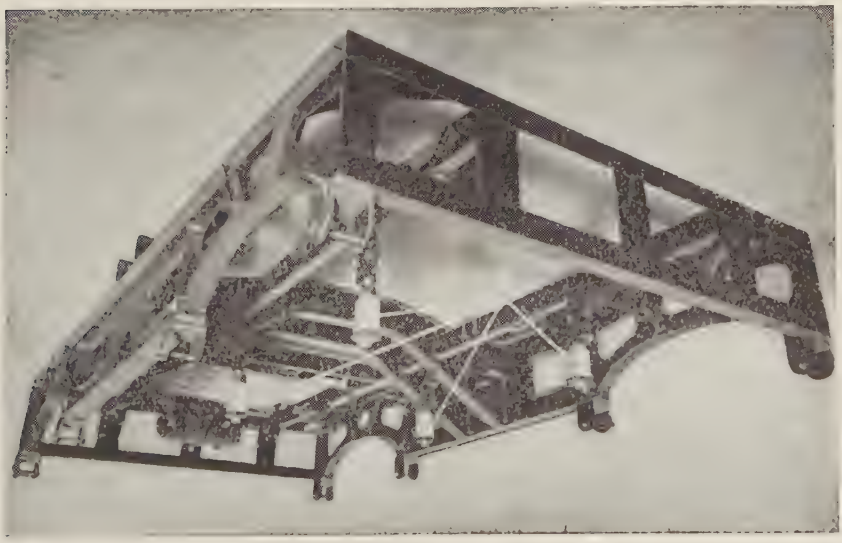


Fig. 11. — J.G.R. bogie frame. Engine subframe is carried on rubber block « A ».

4) Reduced bending stresses due to in line load transfer between frame and axlebox, thus lighter bogie frame.

5) Elimination of hornblocks with attended wear.

6) Appreciably reduced weight.

7) Reduced maintenance expenses.

With standard bogies the clearance between axlebox and hornblocks usually amounts to about 0.5 to 1 mm. in the direction of car travel and about 1 to 3 mm. at right angles to it. Ideally no clearance is aimed at in the first case and a clearance in excess of 1 mm. may lead to axle bunting transferred to the bogie frame and car body, whilst an unduly small clearance will result in friction between hornblocks and axle box, this adversely affecting the riding qualities. If the bogie frame is not built stiff enough — and thus often unduly heavy — then the vertical loads may result in increasing the axlebox clearance, whilst in addition the couple resulting from the springs located on the axlebox outside or inside the frame would tend to twist the latter this under circumstances leading to undue friction between hornblocks and axleboxes. These considerations, with the attendant maintenance problems, are completely absent with the bogies dealt with.

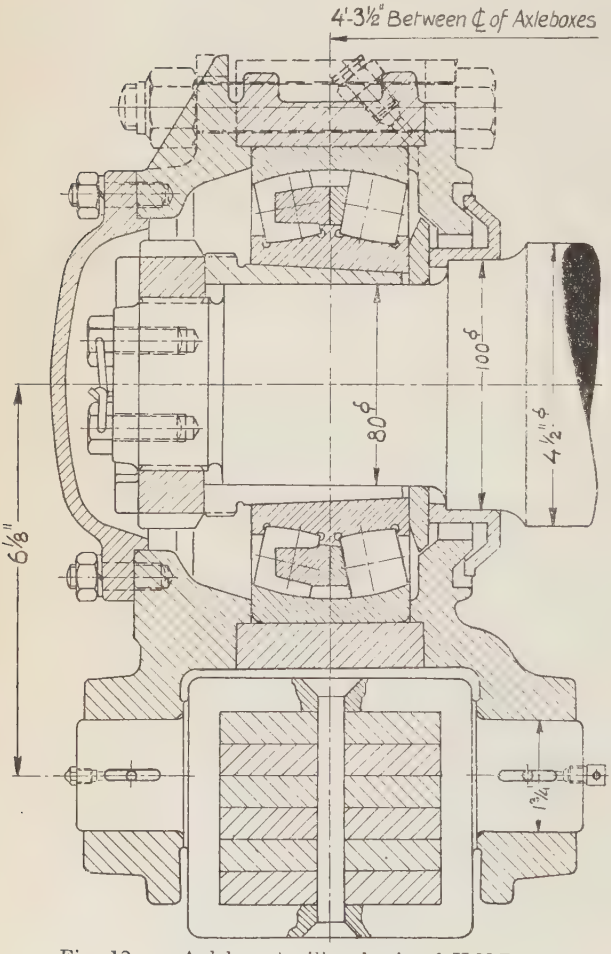


Fig. 12. — Axlebox, trailing bogie of K.U.R. car.

The radius arms should be as long as practicable : they should be linked towards the bogie centre, and the points of location should be slightly higher than the wheel centre. This will ensure a minimum alteration of wheel base due to load variations at the same time providing a steering effect when running through badly or entirely unsuperelevated curves at speed.

It must be admitted that the adopted method of attachment does not strictly meet the requirement for guiding the axles without any play. For one the use of Silentblock bushes does permit a small amount of flexibility, for another the leaf springs used for transverse guidance are also flexible. The latter feature may, however, be desirable on lines incorporating sharp curves. With the bogies dealt with transverse guidance is ensured by two spring leaves, the transverse deflection amounting to 5/32″ when subject to a force equal to 16.5 % of the wheel load,

a condition encountered when passing through a 1.000 ft. radius curve at 50 m. p.h.

The writer considers that the riding qualities of the bogies could be further improved by slightly extending the radius rods. A drawback — though not a serious one — is that the underslung springs prevent the provision of certain portions of the brake rigging outside the wheels *(Fig. 13)* this making the brake adjustement enroute more difficult. That clasp brakes are preferable when using radius rods scarcely needs stressing, particularly when considering that with brake blocks on one side of the wheel only, the radius rod may have to deal both with the force due to brake blocks as well as with that due to adhesion between wheel and rail. The possibility of adjusting the effective radius rod length (by locating the Silentblock bush in an adjustable excentric housing) would be of advantage in securing exact parallelism of the axles particularly on railways removing flat spots on wheels, with the

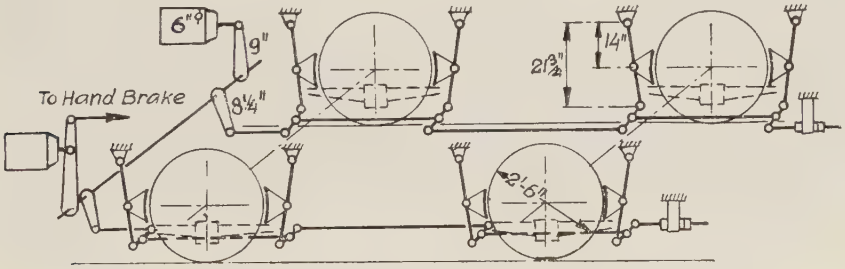


Fig. 13. — Scheme of brake rigging of power bogie, K.U.R. car.

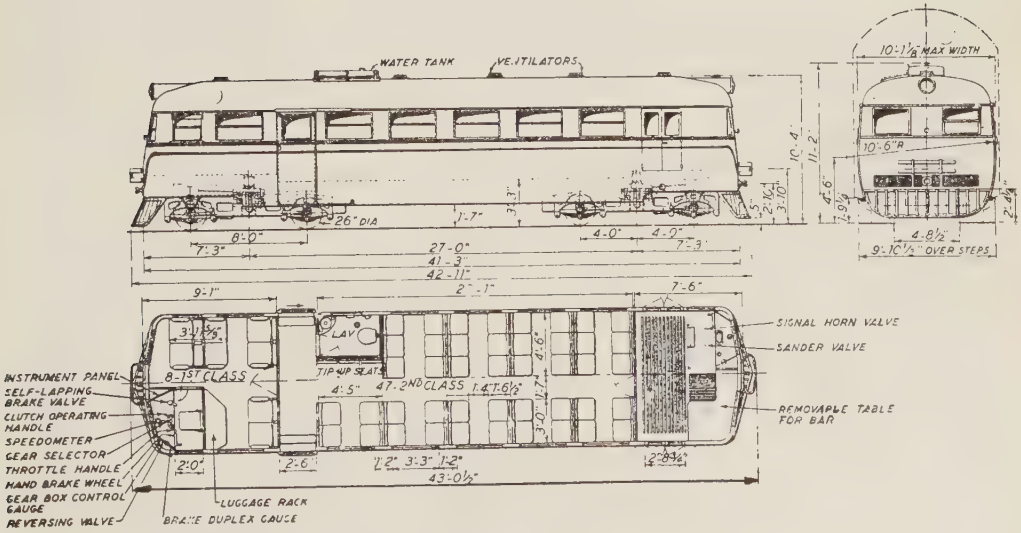


Fig. 14. — Railcar for Jamaica Government Railway.

help of grinders fitted in the shop pit, without removing the axles from the bogie.

The general appearance and main sizes of the vehicles — three of either type were built — will be gathered from *Figs. 14, 15, 16* and *17* respectively.

The double-bogie railcar of the Jamaica

Fig. 15. — View of J.G.R. Railcar.

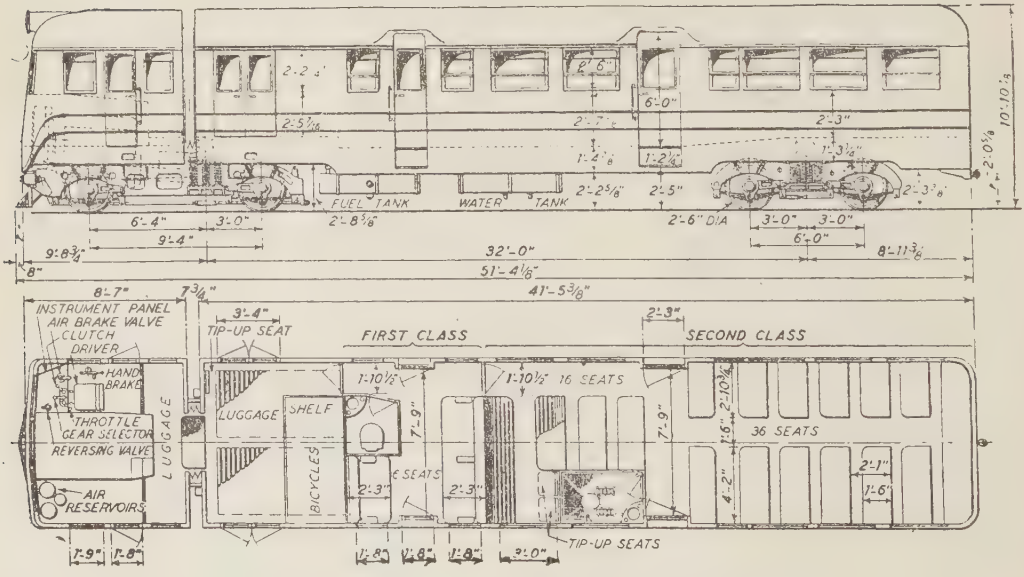


Fig. 16. — Railcar for Kenya and Uganda Railways and Harbours.

Government Railway (J.G.R.) weighs 12.8 tons when ready for operation, the fully laden weight being about 18 tons. Power is furnished by two Perkins Diesel engines each developing 65 H.P. at 1 750 r.p.m. With one car the transmission is of the Mylius pre-selective synchromesh air-operated type, whilst the other two cars were fitted with Cotal epicyclic electro-magnetic gearboxes.

The articulated railcars of the Kenya and Uganda Railways and Harbours (K.U.R.) weigh 17 tons when ready for operation and 24.5 tons when fully laden. The car is driven by a Saurer type BXD six-cylinder 14.34 litres, Buchi supercharged, Diesel engine developing 225 H.P. at sea level, the power being transmitted to one axle via a Mylius transmission.

Whilst the Jamaica cars do not have to operate at high altitudes, the Kenya cars were destined for the Kisumu (Lake Victoria) and Yala branch line running at altitudes of about 3 700 to 4 900 ft. and it is here that a supercharged engine proves to be eminently suitable.

Applying equations (4), (10) and (11) to the bogies of these cars we obtain the values for l, as shown in Table I.

Fig. 17. — View of K.U.R. railcar.

Table I.

Wave Length of Bogie Path.

	l(ft)	E	l_1 (ft)	l_1' (ft)
J.G.R. . . .	45.9	2.04	93.5	88
K.U.R. *(Power Bogie)* . .	41.5	2.93	112.15	118
K.U.R. *(Trailing Bogie)* .	41.5	2.055	85.25	97.7

Whilst the results obtained with the help of equation (10) and (11) do not entirely agree the beneficial results obtained by increasing the wave length from l to l_1, in turn reducing the frequency and particularly the values of b_y and s_y are apparent. The beneficial effect of keeping the axles parallel is in-

dicated by the reduction of the transverse bogie frequency of the Jamaica car from 95.5 to 46.8 cycles per min. when travelling at 50 m.p.h. Similar improvements are obtained for the Kenya vehicle. The importance of reducing the value of f upon b_y and s_y, particularly when considering that the transverse acceleration and shock increase as the second and third power of vehicle speed respectively is clearly indicated by equation (8) and (9).

The suspension system interposed between the car body and bogie should allow an unrestrained movement of the bogie both in the straight and in the curves, it should contribute to comfortable riding and at the same time it should be light and simple. The use of conventional swing links was discarded since they could not be made long enough to ensure a low transverse frequency. In addition their use would increase the bogie weight due to centralising the load and also due to the use of links and members required for this form of suspension. It was considered that the use of coil springs directly supporting the bolster would ensure a satisfactory solution. With this arrangement (1, 12, 16) the weight will be reduced by eliminating links, etc., whilst by using two to three springs on each side the load will be more evenly distributed along the bogie frame. Acceptable transverse frequencies and amplitudes can be obtained by suitably proportioning the springs which in addition are also more readily responsive to transverse forces than swing links. With the latter frictional forces must be overcome before displacement takes place, this resulting in a certain amount of hysteresis, whilst the response of coil springs is almost immediate *(Fig. 18)*.

In order to ensure adequate transverse deflection the bolster springs must be relatively high and this together with the method of loading bringing the spring into the region of columns or struts with the attendant questions of stability. Consequently the prones of a proposed spring to buckling must be ascertained, for this is a deciding factor so far as its suitability is concerned.

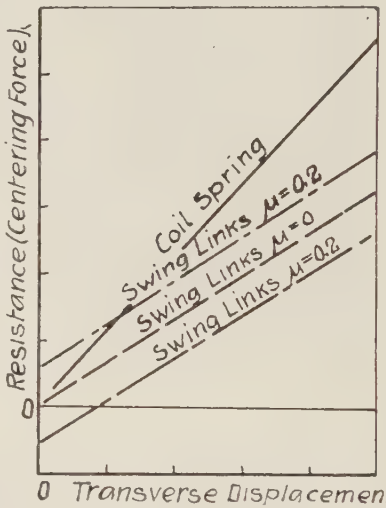


Fig. 18. — Resistance to transverse displacement of swing links and coil springs.

The flexural rigidity of a circular bar is :

$$B_c = E\pi \frac{d^4}{64} \quad . \quad . \quad . \quad . \quad (12)$$

where E = Tension Modulus of elasticity of material (lb./in^2).

d = Bar diameter (in.).

The equivalent value for a coil spring is :

$$B = \frac{L}{\pi . n . r} \cdot \frac{I}{\frac{1}{EI_1} + \frac{1}{G . k_t}} \quad . \quad (13)$$

where

L = spring length (in.)

n = number of active coils

r = Mean radius of spring

$I = \frac{\pi d^4}{64}$ = Moment of inertia of wire section inbending at right angles to the main spring axis.

$k_i = \frac{\pi d^4}{32}$

G = Shear modulus of elasticity of the material (lib./in²).

The shearing rigidity of the coil spring is : (17)

$$S = \frac{EI_2L}{\pi nr^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

where I_2 = Moment of inertia of wire section parallel to main spring axis (For circular section wire $I_1 = I_2$)

For circular section wire the above can be simplified to

$$B = 0.0176 \frac{Ld^4}{nr} G \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$$S = 0.0405 \frac{Ld^4}{nr^3} G \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

With G = 11 500 000 lb./in² for spring steel we have

$$B = 202\,000 \frac{Ld^4}{nr} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15a)$$

$$S = 465\,000 \frac{Ld^4}{nr^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16a)$$

The critical buckling load for the case concerned is expressed by the equation

$$P_c = \frac{B\frac{\pi^2}{L^2}}{1 + \frac{B\pi^2}{SL^2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

which for a circular wire section spring can be simplified by substituting the values for B and S to :

$$P_c = \frac{0.174d^4G}{nrL\left[1 + 4.3\frac{r^2}{L^2}\right]} \quad . \quad . \quad . \quad . \quad (17a)$$

With G having the same value as stated above we have :

$$P_c = \frac{2\,000\,000d^4}{nrL\left[1 + 4.3\frac{r^2}{L^2}\right]} \quad . \quad . \quad . \quad . \quad (17b)$$

The safety ratio $R_s = P_c/P$ (where P = Actual Load) must theoretically exceed unity. However when taking into consideration manufacturing tolerances which may often result in the centre line of the spring slightly departing from the straight line or the ends not being exactly parallel a safety ratio of $R_s = 2$ should be aimed at.

In order to ensure that the load axis would correspond to the geometrical axis of the spring it is suggested that the number of turns should be a multiple of ½.

The determination of the magnitude of transverse deflection of a coil spring can be derived with the help of the corresponding equations of a strut stressed in the axial and transverse direction *(Fig. 19)*. For this the equation of the elastic line is :

$$y = \frac{T}{P}\left(-x + \frac{I}{k} \cdot \frac{\sin kL - \sin k(L-x)}{\cos kL}\right) \quad (18)$$

whilst the transverse deflection is

$$d_T = \frac{T}{P}\left(\frac{\tan kL}{k} - L\right) \quad . \quad (19)$$

The maximum value of the bending moment for X = 0 amounts to :

$$M_{max} = \frac{T}{k} \tan kL$$

Whilst for the strut (18)

$$k = \sqrt{\frac{P}{E \cdot I}} \quad . \quad . \quad . \quad . \quad . \quad (20)$$

for coil spring stressed in compression :

$$k = \sqrt{\frac{P}{B(1 - P/S)}} \quad . \quad . \quad (21)$$

The equations applicable for the simple strut do not take account of the shear deformations in the helical spring due to force T. The resultant value must be added to d_T.

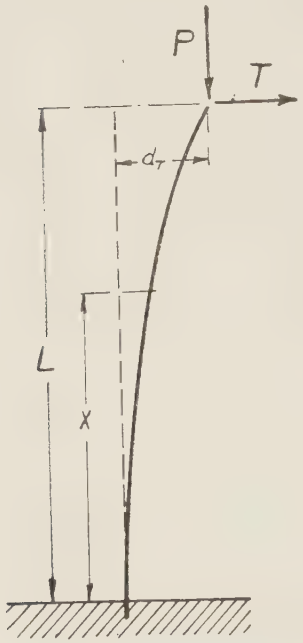


Fig. 19. — Scheme of strut stressed axially and transversely.

The equation of the elastic line or slope of helical spring loaded in the manner concerned is :

$$y = \left\{ \frac{1}{kP} \left[\sin kx - kx - (\cos kx - 1) \tan \frac{kL}{2} \right] + \frac{x}{S} \right\} T \quad . \quad . \quad . \quad . \quad . \quad (22)$$

where x = A point along the centre line of the spring.

The transverse deflection at the end of the spring (y for $x = L$) will be :

$$d_T = \left\{ \frac{1}{P} \left[\frac{2}{k} \tan \frac{kL}{2} - L \right] + \frac{L}{S} \right\} T \quad . \quad (23)$$

whilst the maximum moment (at $x = 0$ and $x = L$) will be :

$$M_{max} = \pm \frac{T}{k} \tan \frac{kL}{2} \quad . \quad . \quad (24)$$

The length L of the spring appearing in the above equations should represent the length of « working » turns only. Since the number of « inactive » turns is not always known with a great degree of certainty it is advisable to obtain the number of working turns by experimentally determining the axial stiffness or specific deflection which in turn gives the ratio G/n.

Generally it will be advisable to provide 1¼ inactive turns at each end of the spring.

The transverse frequency of a helical spring can be derived in a way similar to that applied for a bar subject to similar stress (18).

$$f_T = \frac{1}{2\pi} \sqrt{\frac{C_T g}{T}} = 188 \sqrt{\frac{I}{d_T}} \text{ (cycles/sec.)} \quad (25)$$

Whilst this equation does not take into account the mass of the spring it is con-

sidered that it will give a sufficiently accurate value particularly when taking into account the relative value of T and the spring weight W_s (It may be mentioned that to allow for this, according to Railleigh (18), the denominator under the radical should read $T + 0.236W_s$ instead of T).

The main data for the bolster springs used with the cars dealt with are given in Table II.

Table II.

Bolster Spring Data.

Car.	*Free Height L-inches.*	*No. of Coils.*	*r-inches.*	*d-inches.*	*Vert. Defl. inches /ton.*	*P-pounds (fully laden).*
J.G.R.	10.2	8	2.75	0.875	2.23	2 000
K.U.R. *(Power Bogie)* . . .	17	11	2.75	0.875	3.85	1 370
K.U.R. *(Trailing Bogie)*. . .	16	10.5	2.75	1	2.2	3 210

The resultant values of the flexural rigidity B, shearing rigidity S, critical buckling load P_c and buckling safety ratio R_s are given in Table III. for the springs under full static load P together with the specific transverse deflection.

Table III.

Bolster Spring Factors.

Car.	B	S	P_c-*pounds.*	R_s	*Transverse Defl. inches/ton.*
J.G.R.	45 500	13 800	16 000	8	2
K.U.R. *(Power Bogie)* .	52 500	16 000	5 850	4.27	7.8
K.U.R. *(Trailing Bogie)*	90 000	27 000	8 700	2.72	3.4

The above values have been calculated on the basis of n being reduced by 0.75 so far as B and S are concerned and $2 \times 1.25 = 2.5$ so far as P_c, R_s and the transverse deflection is concerned, since it is to this extent that both ends of each spring are guided at the bolster and bogie frame.

The transverse movement of the bolster is limited to 1 inch to either side of the centre. Since the transverse loads on a vehicle bolster rarely exceed about 20 per cent. of the vertical load, the springs of the three bogie types dealt with are not deflected by more than 0.365, 0.97 and 0.985 inches respectively.

The natural frequency of the transverse vibration of the bolster springs is inversely proportional to the square root of the deflection i.e. since d_T is proportional to T and L and inversely proportional to P (which also affects T) f is mainly affected by d_T. We have thus either low frequency high amplitude or high frequency low amplitude vibrations. At speeds in excess of about 75 m.p.h. it may be required to arrange for dampening the transverse vibrations by means of simple friction type shock absorbers.

In order to reduce bouncing, Houdaille hydraulic shock absorbers have been provided across the coil springs, as with the springs fitted resonance occurs with the vertical frequency at a car speed of about 45 m.p.h. in case of the Jamaica cars, whilst in case of the Kenya cars resonance would be encountered at 41.5 and 36 m.p.h. for the power and trailing bogie respectively.

The type of suspension thus adopted has proved to meet the requirements of overseas service and to quote Mr. H. R. Fox, the general manager of the Jamaica Government Railway : « The track whilst pretty sound and strong is not fetted up in the best condition through lack of funds. There are many low joints and minor slacks, yet the coaches ride most comfortably indeed. You hardly feel any of the unevenness of the track, even travelling at 55 m.p.h. »

* * *

BIBLIOGRAPHY.

(1) Wiens, « Personenwagen in Leichtbauart », Org. Fortschr. Eisenbahnwesens, 1940, Nr 15/16, pp. 237-271.

Taschinger, « Leichtbau D-Zugwagen nach dem Entwurf des Reichsbahnzentralamts München », Org. Fortschr. Eisenbahnwesens, 1940, Nr. 17/18, pp. 273-297.

Robling, « Versuchsdrehgestell für Schnelltriebwagen », Org. Fortschr. Eisenbahnwesens, 1941, Nr. 5 pp. 57-63.

v. Waldstätten, « Neue Drehgestell Konstructionen », Org. Fortschr. Eisenbahnwesens, Vol. 97 (1942), nº 6, pp. 85-89.

(2) Meister, « Die Empfindlichkeit des Menschen gegen Echütterungen », Forsch. Ing-Wes. Vol 6 (1935), p. 116 Z. VDI Vol. 80 1936), p. 136.

(3) Zeller, « Wirkungen von mechanischen Bewegungen auf den menschlichen Organismus », Berlin 1933.

Zeller, « Günstigste Federung bei Fahrzeugen mit Rücksicht auf die Fahrbequemlichkeit », Forsch. Ing-Wes. Vol. 5 (1934), p. 75.

(4) Jacklin and Liddell, « Riding Comfort Analysis », Research Bulletin No 44, Engineering Experiment Station, Purdue University, Lafayette, Indiana, 1933.

Jacklin, « Human Reactions to Vibration », S. A. E. Transactions New York 1936, p. 401.

(5) Helbrig und Sperling, « Verfahren zur Beurteilung der Laufeigenschaften von Eisenbahnwagen », Org. Fortschr. Eisenbahnwesens, 1941, No. 12, pp. 177-187.

(6) Ceasar, « Schlingerbewegungen von Drehgestellwagen », Org. Fortschr. Eisenbahnwesens, 1929, Nr. 24, p. 501.

(7) Heumann, « Lauf des Drehgestell = Radsätze in der Geraden », Org. Fortschr. Eisenbahnwesens, 1937, No 7, pp. 149-173.

(8) Heumann, « Lauf von Eisenbahnfahrzeugen mit zwei ohne Spiel gelagerten Radsätzen in der Geraden », Glasers Annalen, Vol. 62 (1938) Nr. 3 and 4, pp. 25-30, 43-48.

Pochet, « Théorie du mouvement en courbe sur le chemin de fer », Paris 1882.

Bodecker, « Die Wirkung zwichen Rad und Schiene », Hannover, 1887.

Marié, « Les oscillations du matériel dues au matériel lui-même », Revue Générale des Chemins de Fer, 1906.

Carter, « The Electric Locomotive », Proceedings of the Inst. of Civil Eng. Vol. CCI, London 1916.

Ruegger, « Die Konizität der Radreifen und die Fahrt auf gerader Strecke », Zurich, 1916.

Mauzin, « Etude sur le lacet de véhicules », Revue Générale des Chemins de Fer, 1933.

Kreissig, « Das Reibungsgleichgewicht starrgelagerter Radsätze beim Lauf in der Geraden », Glasers Annalen, Vol. 115, No 11, p. 97.

Rocard, « La Stabilité de Route des Locomotives », Paris, 1935.

Cain, « Safe Operation of high-Speed Trains », A. S. M. E.. Transactions, Vol. 57 (1935), p. 471.

Langer and Shamberger « Lateral Oscillations of Rail Vehicles », A. S. M. E. Transactions, Vol. 57 (1935), p. 481.

Davies, « Some Experiments on the Lateral Oscillation of Railway Vehicles », Journal Inst. Civil Eng., March 1939, p. 224.

(9) Cain, « Vibration of Road and Rail Vehicles », Pitman, New-York, 1940.

(10) Heumann, « Lauf von Eisenbahnfahrzeugen mit zwei ohne Spiel gelagerten Radsätzen », Org. Fortschr. Eisenbahnwesens. Vol. 95 (1940), No 3 and 4.

(11) Heumann, « Lauf von zweiachsigen steifachsigen Triebfahrzeugen», Org. Fortschr. Eisenbahnwesens, Vol. 97 (1942), No 1, pp. 1-10.

Heumann, « Zum Schlingern von Eisenbahnfahrzeugen », Org. Fortschr. Eisenbahnwesens, Vol. 98 (1943), Nr. 15/16.

(12) Sanders, « Springs, A. Miscellany », Vol. II, pp. 782-865, Locomotive Publishing Co. London, 1943.

(13) Koffman, « Are Hornblocks Necessary? », Passenger Transport Journal, London, January 9th. 1942, pp. 15-19.

(14) Hug, « Die neuen Strassenbahnwagen in Genua », Verkehrstechnik, 1941, No. 10, pp. 143-148.

(15) Reiter, «Werkstättentechnik für den Bau geschweisster Schienenfahrzeuge », Org. Fortschr. Eisenbahnwesens, Vol. 95 (1940), No. 10, pp. 153-160.

Maurer, « Anbrüche an Trieb-, Steuer- und Beiwagen und ihre Auswertung für geschweisste Konstruktion », Org. Fortschr. Eisenbahnwesens, Vol. 95 (1940), No. 11, pp. 167-175.

Reiter, « Die Arbeitsverfahren beim Bau geschweisster Schienenfahrzeuge », Org. Fortschr. Eisenbahnwesens, Vol. 96 (1941), No. 6, pp. 75-84.

(16) Hug, « Automotrices sur les Grands Réseaux d'Espagne ».

Ahrens, « La Suspension Transversale des Véhicules sur Rails », L'Allègement dans les Transports, 1936, No. 5/6.

Stuhr, « Die wagenbauliche Konstruktion des Einheitsstrassenbahnwagen », Verkehrstechnik, 1941, No. 11-12, pp. 174-184.

(17) Gross, Lehr und Speer, « Die Federn », Berlin 1938, pp. 94-100.

(18) Den Hartog, « Mechanical Vibration », New-York 1934, p. 39.

[625 .212]

Safe stresses in axles.

Determination of axle shape and dimensions,

by M. KAMMERER,

Inspecteur divisionnaire au Laboratoire
du Service Central du Matériel de la Société Nationale des Chemins de fer français.

(Revue générale des Chemins de fer, September-October 1945).

During the years 1936 to 1940, a considerable number of breakages occurred in autorail axles, chiefly among those made of special high-tensile steel, although these axles had been designed in accordance with the customary formulae and with existing carbon steel axles as prototypes. The permissible working stress had been raised in proportion to the ratio of the respective tensile strengths to the special steel and the carbon steel previously used.

Laboratory examination of the broken axles showed that in most cases the metal possessed the requisite mechanical properties in respect of tensile strength, elongation and notched-bar resistance. Consequently upon these at first inexplicable failures, a systematic study of the intensity of elastic stress in the axles was undertaken so as to assess the nature (steady or fluctuating) of the stress concentrations and the extent to which the different steel withstand them.

An explanation of the observed fractures was obtained and led to the development of a new method of calculation for axles concerning which the S.N.C.F. has issued a technical bulletin.

We shall here summarise the methods previously used by the S.N.C.F. and, after considering in order the different factors involved in the determination of the form and dimensions of axles and wheel-bosses, we shall briefly review the proposed new method of calculation together with the advantages to be expected from its adoption.

A. METHODS OF CALCULATION FORMERLY IN USE.

Various methods were in use. To take examples:

In the case of *electric stock* the axles were made of 35-ton steel and were calculated :

1. Under the action of the static load alone. Experience showed that the maximum working stress should not exceed 2.5, 1.5 and 3.0 kgr./mm² (1.6, 0.95, 1.9 tons/in.²) in the body of the axle, the wheel seat and the journals respectively.

2. At the limits of wear of the motor bearing seat and the journals under static load when starting up, keeping the stresses due to the weight of the vehicle and the motors on the one hand, and to propulsion and braking forces on the other, below 10 kgr./mm² (6.35 tons/in²).

For *steam locomotives* the calculation for straight axles covered only the static load on the journals, the wheel seat and the body of the axle.

An exception was made in the case of crank axles, the permissible working stress being increased to cover lateral shocks.

The accepted limits for trailing engine axles, driving or coupled axles and tender axles were 4.5, 3.5 and 5.5 kgr./mm² (2.9, 2.2 and 3.5 tons/in²) respectively. Torsional stress was kept below 5 kgr./mm² (3.2 tons/in²).

These methods are open to the following criticisms :

1. The extremely low working stress

(down to 1.5 kgr./mm² [0.95 tons/in²] in a 35-ton steel) which shows the inadequacy of the calculation.

2. No account is taken of live overload or, save to a limited extend in crank axles, of lateral shocks resulting of high speeds.

3. The same may be said of the stresses due to pressing-on the wheels, and

4. of the influence of shape, which is an essential factor.

5. The combined effects of stresses arising from different causes were not correctly calculated, particularly for bending and torsion.

From 1936 to 1940, designs for autorail axles did take into account the stresses due to wheel mounting and, to some extent, those arising from live overload and lateral shock. They still, however, ignored the effect of axle shape and of the inherent qualities of the steel used, the influence of which is not to be judged from consideration of its endurance limit of tensile strength alone.

B. STUDY OF THE PRINCIPAL FACTORS.

I. Live load and overload.

The dynamic forces to whose existence we have referred may be divided into two categories :

1. *Fluctuation of the vertical loads applied at the journals.*

These are due,

(*a*) To the rolling moment of the vehicle, which subjects the journal alternately to a load varying between $\frac{P}{2}$ and $\frac{3P}{2}$, P being the static journal load.

(*b*) To vertical shocks which, in the case of vehicles not fitted with coil springs, impose oscillations of amplitude $\frac{P}{2}$ upon the load curve given by the rolling moment.

When the vehicle is coil sprung (coaches) the shocks may be neglected.

2. *Lateral shocks.*

Nosing of the vehicle gives rise to forces F acting transversely between the underframe and the axle and, consequently, between the wheel flanges and the rails. These forces may attain a maximum value equal to P for motor coaches and $\frac{2P}{3}$ for trailers. From these data we have determined those combinations of the journal loads P_1, P_2 with the lateral reaction F, which result in these forces exerting their maximum bending moment at the principal sections of the axle in the journal, the wheelseat and the mid-section of the axle body.

The maximum bending moment at any given section may then be very easily determined from the preceding three particular cases.

By way of example, let us consider the case of a locomotive axle with wheels 2 metres in diameter, the distance between centre line of wheelseat and centre line of inner journal being 250 mm. and the distance between centres of rails effectively the same as that between wheelseats. The bending moment exerted at the mid-section of the wheelseat by the static load is equal to 250 P. Under the action of dynamic load plus overload this, according to our formulae, becomes $(1\,000 + 2 \times 250)P$ or six times the static value.

II. Driving forces.

Both driving and coupled locomotive or autorail axles have to withstand the thrust of the driving mechanism in the form of additional bending moments and torque.

Bending moments. — Moments about a horizontal axis due to vertical components of the propulsive effort may easily be calculated, when the driving axle is not coupled, by the classic equations of statics and the strength of materials. This applies whatever system of propul-

sion is used (electric motor suspended at nose, spur or bevel gearing, inside or outside connecting rods).

In the case where the driving axle is coupled to others, the coupling rod reactions cannot be simply determined (the system being hyperstatic) except when one of the rods is on dead centre and is doing no work. It is necessary for the purpose of calculation to assume that the coupling rods are in this position.

Moments about a vertical axis due to horizontal forces are also more difficult to calculate, the axle supporting four thrusts : the horizontal reactions of the two rails and the two axlebox guides (hyperstatic system).

The horizontal reactions at the rails are equal to $\varphi_1 P'$ and $\varphi_2 P'$, φ_1 and φ_2 being the coefficients of friction between tyre and rail and P' the vertical load upon the rail. φ_1 and φ_2 vary between zero and a maximum value which may be put at 0.3. Under these conditions, it is possible to find among the following combinations one which gives the maximum value for bending moment about a vertical axis at the different parts of the axle in which we are interested :

$$\varphi_1 = 0 \qquad \varphi_2 = 0$$
$$\varphi_1 = 0 \qquad \varphi_2 = 0.3$$
$$\varphi_1 = 0.3 \qquad \varphi_2 = 0$$
$$\varphi_1 = \varphi_2 = 0.3$$

(or the highest value permitted by the driving couple).

Torsional couple. — For a *driving or trailing axle, not coupled,* the maximum permissible torque applied between wheels may be as high as $0.3P'R$, where P' is the load transmitted to the rail by the wheel, R the wheel radius and the highest coefficient of friction is taken as 0.3.

In the case of a *coupled driving axle* the torque may exceed the value $0.3P'R$, in particular when skidding, the driving couple being applied at midspan and transmitted to the other axles by coupling rods. It is necessary to determine for each individual case the greatest torque applied to the axle, according to the type of driving mechanism and its disposition.

The application to various types of axle of the formulae derived from the foregoing considerations, shows that torsional stresses are always low compared with bending stresses and that they may therefore be neglected, at least in first approximations.

III. Wheel mounting.

The theory of elasticity permits complete determination of the stresses produced by the force fit of a collar upon a disc of the same thickness. The grip on the disc gives rise to two principal compressive tresses of equal magnitude v_0, the third stress being nil. In the collar one of the principal stresses ν_1 is a radial compression varying in magnitude between ν_0 and zero (Fig. 1). The

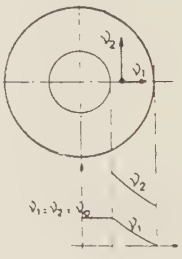


Fig. 1.

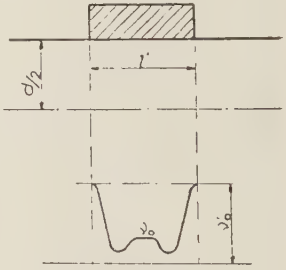


Fig. 2.

other, ν_2, is a circumferential tensile stress which reaches its maximum at the contact face between the two members.

When the wheel boss is mounted on an axle of uniform diameter in the vicinity of the wheel seat, photo-elastic sur-

vey (1) of a section of the assembly taken through an axial plane shows (Fig. 2) that at the extremities of the wheelseat there exist stress concentrations of magnitude γ'_0. We have been able to determine the law connecting γ'_0 with the calculated value γ_0, as a function of the ratio of the length l' of the boss to the diameter d of the axle.

These results have led to the adoption of one or other of the two shapes of wheel boss shown in Fig. 3.

(1) On the left, boss tapered off at each end. The theoretical calculated

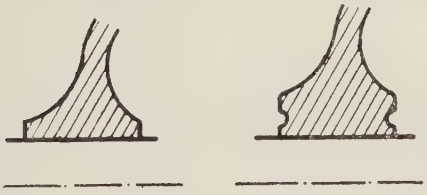


Fig. 3.

stress at these points is thus diminished so as to compensate for the concentration of stress.

(2) On the right, boss provided with stress relief grooves, which serve the same purpose as the taper but are perhaps rather less effective.

If the wheelseat is of larger diameter than the neighbouring portions of the axle, the photo-elastic method again permits determination of both the location and intensity of the stress concentrations for various types of connecting fillet between the wheelseat and the body of the axle (sharp or rounded corner) and for varying ratios of wheelseat to body diameter. Fig. 4 gives two examples of stress distribution. In the case of the rounded corner the skin stress falls from a maximum at B to zero at A where the fillet starts.

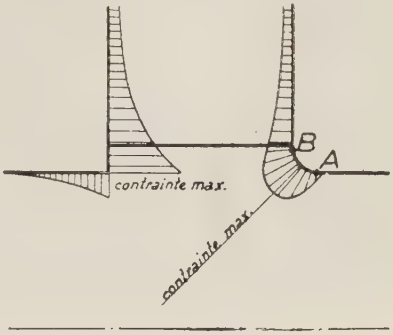


Fig. 4.

The photographs in Fig. 5 show the isochromatics (lines of equal difference of magnitude between the principal stresses) for the respective cases of an axle of constant diameter and one with a raised wheelseat approached through a sharp corner and through a fillet.

The theory of elasticity supplemented by photo-elasticity enables us to estimate the steady stresses in the axle resulting from the force fit of the wheel. It also permits calculation of the grip required in terms of the maximum applied torque, which is equal in most cases to $\varphi P'R$. For this purpose the coefficient of friction between boss and wheelseat, for the condition known as « tallow wiped », is taken as 0.1. This value has been confirmed by experiment with force fits between collars and shafts, as has also the accuracy of the formulae derived by us.

In the wheel boss, whatever its external diameter may be, the difference between the principal stresses is equal to the product of the elastic modulus for steel multiplied by the ratio of force fit interference to wheelseat diameter.

IV. Abrupt changes of diameter.

The classic formulae for the strength of materials enable us to calculate bend-

(1) See the treatise on photo-elasticity (photoélasticimétrie) by Leboiteux and Boussard, and the Author's own « Researches into Photo-elasticity » (Recherches sur la Photoélasticimétrie) (1944) both published by Hermaure (No. 960 of *Actualités Scientifiques*).

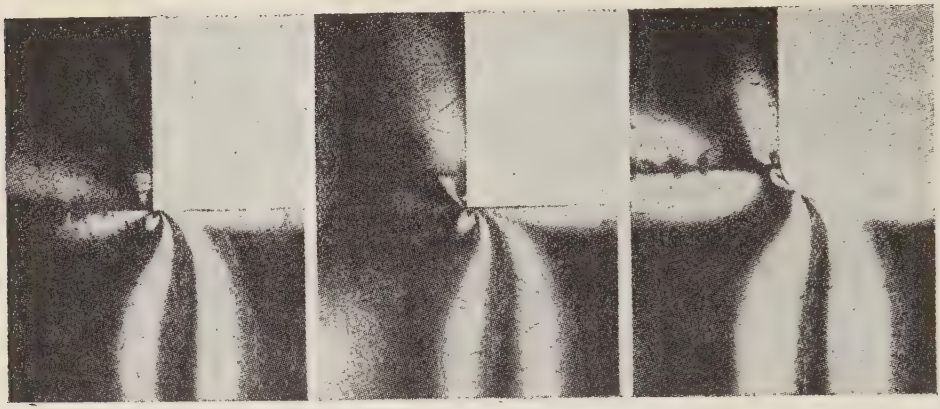


Fig. 5.

ing stresses in long members of either constant or *slowly varying* cross section. Axles, however, always incorporate *notable changes* of section (journals, wheelseat, and body). We have used photo-elastic methods to study the stress distribution in beams of rapidly changing cross-section, for different forms and dimensions of connecting fillet and for different ratios of diameter and length of raised portion to diameter of smallest section.

Circular fillet. — Sections connected by a fillet comprising one circular arc only; either a whole quarter-circle or a shorter arc of larger radius (Fig. 6).

The photo-elastic method has been used to measure the intensity of stress concentration at the commencement A of the fillet, as a function of fillet radius and the ratios of

(*a*) length of raised portion to diameter of smallest section and

(*b*) diameter of larger to smaller section.

To take an example : at a raised collar twice the size of the reduced diameter and of great length, a sharp corner produces a stress concentration of 80 % while a fillet of radius equal to one half the diameter of the smaller section completely removes all local stress. A collar of length less than the radius of the smaller section gives rise to no stress concentration even if sharp-cornered.

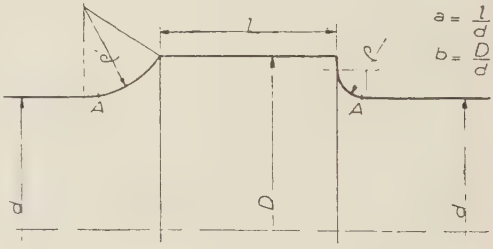


Fig. 6.

Transition by several circular arcs. — The fillet described above may be replaced by a compound one made up of two circular arcs (Fig. 7) of radius ρ and ρ'. If δ is large enough (but smaller than ρ) the concentration at A is determined by the radius ρ ragardless of ρ'. With diminishing δ, and constant ρ, A approaches B and, below a certain value for δ, the stress concentration will depend upon the radius ρ' and will therefore be intense.

Wheelseat. (*a*) *Axle of constant diameter.* — It has been established that the axle and the wheel boss form one unit after pressing-on and that there exists in

these members a system of internal stresses superimposed on those due to bending.

This being so, the outside diameter of the boss (D) and the axle diameter (*d*) are sufficient for calculation of the stress

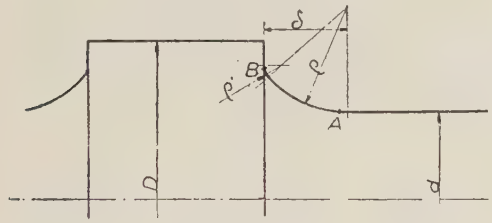


Fig. 7.

increment at the sharp corner produced by flexure.

(*b*) *Raised seat.* — In this case the transition should be effected by a fillet developed in accordance with the principles established by experiments upon fillet contour and force fits.

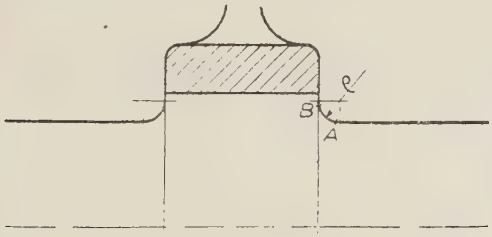


Fig. 8.

At the commencement A of the fillet (Fig. 8) the stress increment due to bending reaches its maximum while that due to the force fit vanishes, which illustrates the essential feature of this arrangement whereby :

(1) The maximum bending stress is decreased by the presence of a fillet, and

(2) The maxima due to flexure and to force fit are separated, the latter becoming negligible where the former is greatest.

V. Endurance.

When at any point in a ductile material such as steel there exist three steady principal stresses $\nu_1 > \nu_2 > \nu_3$ the condition for completely elastic strain is

$$\nu_1 - \nu_2 < L'$$

where L′ is the elastic limit in pure tension equal, for this material, to that in pure compression. In the case of brittle materials the conditions are rather more complicated. (1)

Endurance. — At any point where there is one *principal alternating stress* ν, the remaining two being zero, the condition for resistance to fracture over an infinite number of reversals is that ν shall remain below a certain value known as the « endurance limit » represented here by L.

This endurance limit is here understood to be that obtained from push-pull tests, and is not dependent upon the diameter of the test bar. Under rotating-beam tests the endurance limit, which may equal the above in test bars of large diameter, is found to rise when the diameter falls below a value determined by the nature of the metal.

If an element of a ductile body is subjected to three principal alternating stresses $\nu_1 = K_1\nu$, $\nu_2 = K_2\nu$, $\nu_3 = K_3\nu$ and ν varies from $-\nu_0$ to $+\nu_0$ the condition for infinite resistance to fracture is that the stress given by the largest Mohr circle $(K_1 - K_3)\nu_0$ shall be lower than the limiting safe stress L. (1)

Case of steady stress and an alternating stress in the same direction.

It is assumed that at a point within a body there exists a steady principal stress ν_1 and an alternating principal stress ν_2 acting along the same axis, the two remaining principal stresses being zero. Experiment shows that the maximum permissible amplitude L″ of the alternating stress ν_2 for resistance to fracture over an infinitely large number of reversals falls below the value L as

(1) Caquot's « Courbes Intrinsèques ».

the mean stress rises from zero. It is thus necessary to prepare a diagram showing the safe limits for alternating or pulsating stress (ν_1 and ν_2 superimposed) as a function of the mean stress ν_1. (1)

Case of axles.

(*a*) *Sections other than the wheelseat.* — The stresses alternate and the appropriate limit is therefore L, the endurance limit.

(*b*) *Section at each extremity of wheelseat.*

(1) *If the axle is of constant diameter,* then at the extremities we have :

- *Stresses due to the force fit,* such that two principal steady stresses are respectively radial and tangential to the circumference of the axle section, and the third zero.

— *Stresses due to repeated reversed flexure,* along axes which follow the deflected form of the axle and are therefore perpendicular to the two foregoing.

There are no experimental results available from which we may deduce the combination of steady and alternating stress necessary to ensure that the endurance limit is not exceeded. The few experiments reported by Cazaud are insufficient.

(2) If the *axle has a raised wheelseat,* then at the start of the connecting fillet (point A, Fig. 8) where the stress due to force fit is zero, there subsists only the alternating bending stress which at this point reaches its maximum amplitude. The requisite condition for immunity from fracture is therefore simple : the amplitude must not exceed the endurance limit L.

At the other end of the fillet, at B, the steady force fit stress is a maximum while the alternating bending stress is very low. The former is however always low compared with the elastic limit or even the endurance limit, and so the working stress at B is always lower than at A.

The possibility of making a correct calculation constitutes the third advantage offered by the raised form of wheelseat connected to the body of the axle by suitable chosen fillets.

VI. Notch effect.

Tests under repeated bending, rotating or otherwise, carried out on testbars of annealed mild steel and embodying raised collars with fillets of varying radius, have given results entirely in accordance with the findings of photo-elastic surveys of models presenting the same changes of section. From the apparent diminution of the endurance limit it is possible to derive *a step-up correction factor* corresponding to the maximum local stress increment.

The foregoing applies particularly to notched test bars where the radius at the root of the vee (Fig. 9) is very small.

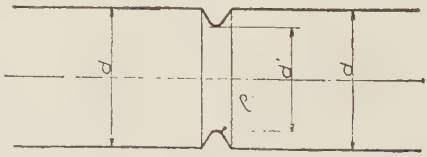


Fig. 9.

Test bars of identical form but made of high carbon steel or heat treated special steel, show a sharp apparent lowering of the endurance limit which becomes even more marked with increasing tensile strength in the steel chosen.

Since axles necessarily embody numerous changes of section notch effect thus leads to the exclusion of high-tensile steels.

(1) « Fatigue of Metals » Cazaud and Persoz (1943 edition).

VII. Internal stress.

The heat treatment of certain steels produces internal stress in the process of quenching which the tempering operation only partly relieves.

This internal stress may have different origins : the piece is suddenly cooled from a high temperature in a bath. Its surface layers harden, thus compressing the still warm interior and placing the external crust in tension. On cooling out, the interior endeavours to occupy less than its original volume, so that when the whole mass is cold the exterior is in compression and the interior in tension.

Fig. 10 represents the manner of variation of the internal stress produced in a rapidly cooled cylinder of plexiglass (photo-elastic determination).

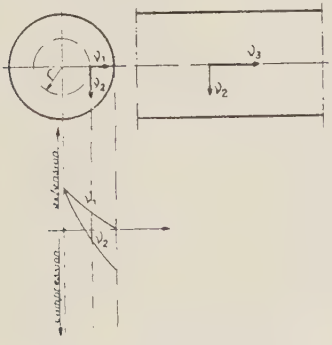


Fig. 10.

If, in the course of cooling a steel specimen, the elastic limit is exceeded at any point in the already cold external crust, the amount of permanent local deformation (cold work) will determine the magnitude of the internal stress to be superimposed upon the preceding ones.

The intensity of internal stress induced by heat treatment increases in the vicinity of sharp variations of contour or cross section (connecting fillets) and the existence of such stress is probably not without influence upon the notch-sensitivity of the harder treated steels.

VIII. Summary.

(1) We have seen from the foregoing that it is possible to calculate the stresses produced in axles by dynamic loads and overloads, by lateral forces, propulsive forces, the pressing-on of wheels and abrupt changes of section. We can make allowance for the nature of the steel (notch effect) by varying the factor of safety according to the type of steel and its treatment. The only factor which it is difficult to assess with accuracy is internal stress, the magnitude of which is not known. We shall be obliged to compensate for this by slightly increasing the factor of safety.

(2) So far as the composition of the stresses is concerned it is sufficient in the case of axles of uniform body and seat diameter to calculate, for all sections save the wheelseat, the maximum stress under alternate bending plus an increment for change of section. This value must fall below the push-pull endurance limit divided by a factor of safety which will take into account the type of steel and, to some extent, the unknown internal stresses.

At the extremities of the wheelseat in axles of constant diameter (unreinforced wheelseat) the principal resultants of the elastic systems arising from flexure and the force fit may be determined photo-elastically.

In the absence of precise data we postulate that the stress equivalent of the diameter of Mohr's circle for the resultant system shall not exceed the endurance limit divided by a factor of safety very nearly equal to unity for untreated steels. In thus neglecting the internal stresses we offset to some extent the fact that this condition is definitely too stringent.

However, in the case of the new de-

signs with raised wheelseats, which can be correctly calculated, the foregoing not entirely satisfactory calculation is not applied. Its practical interest lies in its use as a check upon existing designs.

(3) The breakages of autorail axles are explained by the following considerations :

(*a*) The interference allowed for the wheel fit on axles of constant diameter was too great. Hitherto only the upper and lower limits of the maximum pressing-on tonnage were specified, but these tonnages are essentially determined by the mode of lubrication.

The revised instructions for mounting wheels on autorail axles fix the appropriate shrinkage as a function of the diameter.

(*b*) The dimensions of the axles calculated on the basis of tensile strength were too small. They should have been related to the push-pull endurance limit which rises less rapidly than the breaking stress.

(*c*) The marked sensitivity of high-tensile steels to notch effect brings us to consideration of a suppositional endurance limit, lower than that obtained from push-pull tests on specimens of constant diameter. This in turn leads to a further increase in axle diameter.

C. PROPOSED METHOD.

This will apply particularly to new axles, for which it recommends preferred contours and offers a method of calculation.

For existing axles whose form frequently has no rational basis, it indicates a method of calculation and, if the preceding recommendations are followed, will facilitate weight reduction through improvement of contour.

All that may be given here is a brief outline of the method which has been set out in a S.N.C.F. technical bulletin.

I. Proportions of axle and wheel boss.

Characteristics of the steel used.

This section indicates in precise fashion the ratio of wheelseat diameter to body diameter, the shape of the boss, the contour and relative dimensions of the fillets connecting the different parts of the axle : journals, wheelseats and body of axle. The rules for these and for journal length are all derived directly from the experimental photo-elastic studies and theoretical considerations previously outlined.

It also describes the characteristics of both annealed and hardened carbon steels : endurance limit, elastic limit, breaking stress. For instance these might be 27, 36 and 56 kgr./mm² for a medium carbon steel as annealed (17.1, 22.8 and 35.6 tons/in²) and 28, 38 and 60 for the same steel hardened and tempered (17.8, 24.1 and 38.0 tons/in²).

The highest breaking stress at which it is permissible to use the lowest factor of safety at the inner end of the wheelseat is 70 kgr./mm² (44.5 tons/in²). When the breaking stress rises above 100 kgr./mm² (63½ tons/in²) the highest factor of safety must be taken in order to cover notch effect. Between 70 and 100 kgr./mm² intermediate values are chosen.

II. External forces acting upon the axle and their moments.

In this section the following factors are analysed for trailing axles with either outside or inside journals, and for driving axles :

— Vertical and lateral dynamic overload, giving formulae for maximum bending moments at different sections;

— Torsional forces, with formula for maximum torque;

— Forces due to pressing-on, giving the formula for maximum press tonnage and the greatest torque that the wheel

will transmit without damage to the force fit.

With regard to bending moments imposed by the propulsive forces we have seen that each individual problem must be resolved by statical methods.

III. Calculation of axles.

The same types of axles are covered as before. Formulae are given for maximum permissible working stress at the extremities of the journal (transition from journal to wheelseat) and of the wheelseat, — without or with provision for force fit stresses according to whether the wheelseat is or is not raised — as well as in the section at mid-span of the axle.

In each case the appropriate factor of safety is given.

Attention is also given to correction factors for use with hollow axles.

IV. Fixing the dimensions of the wheel boss.

In this section are defined the relationships which link wheel boss and wheelseat sizes, type of boss, interference fit, and nature of material employed, with the maximum turning effort that the wheel will carry without risk of damage to the fit. This effort must always be greater than the maximum driving torque (factor of safety).

The fact that the maximum working stress in the wheel boss must remain lower than the elastic limit of the steel of which the boss is made determines the sizes of the wheel boss and the axle, and the appropriate force fit allowance.

In this calculation the magnitude of the working stress in the axle is critical only when the wheelseat is not raised.

V. Values of various coefficients.

This section gives, in tabular form, the admissible values for the coefficient of friction between tyre and rail or hub and axle, as well as for the various safety factors, having regard to the type of steel, the section chosen and the form of the wheelseat. For example the factor of safety is 1.1 for the section at the inner extremity of the wheelseat when this is of the same diameter as the axle. It is 1.4 for a raised seat and, for tensile strengths above 100 kgr./mm², ranges from 1.9 to 2.5 depending upon the contour of the wheelseat.

D. CONCLUSION.

To summarise, we have seen that an explanation of the breakages of autorail axles has been provided by :

(1) Calculation of the greatest moments exerted by the normal and the augmented dynamic loads, and lateral shocks, based upon the results of investigations in service.

(2) Determination of the maximum stresses due to these moments and to the wheel fit, from data provided by application of the theory of elasticity and of photo-elastic studies of the influence of axle and hub form.

(3) Study of the mechanical properties of the steels used (with special reference to elastic- and endurance-limits) and of their dependance upon the choice of type (notch effect in high-tensile steels).

The foregoing experiments have served to explain the breakages in autorail axles and to establish methods of *calculation of particular value in the design of new axles* or *the reduction of stress in existing axles* (improvement of boss, wheelseat and fillet contours). It has been possible to bring factors of safety down to values sligthly greater than unity at the most heavily loaded sections (extremity of wheelseat) in carbon steels, the only unknowns being the magnitudes of the internal stresses.

This method, while offering no serious difficulty in its application, must how-

ever be in the hands of staff who are conversant with the strength of materials. They must also be capable of assessing without fail the requirements of the type of axle under consideration (form of wheelseat and fillets...) and of calculating the bending moments due to propulsive forces, which vary from one type of axle to another.

One thing can be said of all attempts to apply a new method (be it developed from photo-elastics or from strain measurement) to a closer determination of the true facts : we are inevitably led to the consideration of formulae more complex than any derived from the classic studies of the strength of materials. Moreover, with these latter we are obliged to use factors of safety of 3, 4 and even 8; which is in effect an admission that the calculations do no more than furnish a comparison with such existing examples of similar type as have proved themselves satisfactory.

Tickets,

by Mr. Lionel WIENER,

Professor at the University of Brussels.

PART E.

TICKET REPRESENTATION OF TARIFFS. SPECIAL TICKETS. *(Concluded*.)*

CHAPTER XXVII.

Other tickets issued by the Companies.

A. —Transport of certain animals.

Certain animals are carried sufficiently frequently to justify the issue of pre-printed tickets for fixed routes, both single and return; for other journeys blank Edmonson or universal tickets are used.

There are special tickets for dogs nearly everywhere, not only on the main line railways but also on secondary lines and tramways (1).

Dog tickets. (Scale 4/5.)

Fig. 1024. — *Andalousian Railways.* — Back of a ticket. — With drawing.
Fig. 1025. — *Oesterreichische Verbindungsbahn* ticket. — With drawing.
Fig. 1026. — *Prussian State Rys.* (1899) ticket. — With drawing.
Fig. 1027. — Return ticket for a kennel. — *Paris-Orleans Ry.*

(*) See *Bulletin of the International Railway Congress Association*, No. of March, May, July and September 1938, p. 217, 473, 665 and 893; No. of July 1939, p. 673 (beginning of *Part E*); No. of September 1946, p. 267 and No. of October 1946, p. 325.

(1) Paper tickets with small drawing issued by the *Tramways de Nice et du Littoral.*

To make them easily recognisable they frequently bear a drawing of a dog (1). We have already illustrated some examples of such tickets (Figs. *626*, *627*, *672*), and further examples are shown here (Figs. 1025-1026).

Such drawings, sometimes merely consisting of a dog's head (Fig. 1024), are generally printed in black like the rest of the ticket, but sometimes in red (2), while they are also used as a background, in which case they are printed in blue or green (3) (Fig. *677*).

There are certain restrictions on the transport of such animals, which are often printed on the ticket. These sometimes dealt with the seat that the dog must not occupy (4), more often with the fact that the Company concerned did not accept responsibility or only limited responsibility (5).

For some time most Companies have adopted zonal rates for dog tickets. There are also return tickets (Fig. *626*).

Such tickets are very often Edmonson tickets. When there is no drawing, the

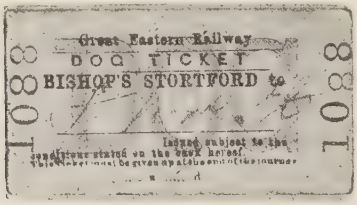


Fig. 1028. — Dog ticket (Scale 4/5). Overprinted with the category. *Great Eastern Ry.*

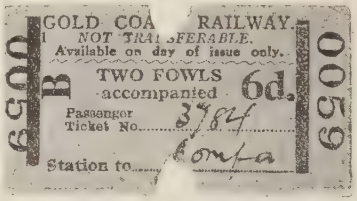


Fig. 1029. — Ticket for two fowls accompanied. — *Gold Coast Ry.* (Scale 4/5.)

Fig. 1030. — Dog ticket. — *Nice and Coast Tramways.* (Scale 3/4.) — With drawing.

(1) In England only the *Great Central Ry.*, the *North Wales Ry.*, the *Liverpool Overhead Ry.*, and a few other Companies.

(2) Overprinted with letters outlined and cross hatched in red on the *Great Western Ry.*

(3) Overprinted in blue or green on the *P.L.M.*

(4) « One dog not to occupy seat », *London Passenger Transport Board.*

(5) *L.P.T.B. Bournemouth Tramways :* « Conveyed at owner's risk ». *Great Western Ry. :* « Value not exceeding £ 2 ».

word « Dog » or its equivalent is prominently displayed. Some tickets bear fairly complicated markings (1).

Paper tickets are also used, however, even for return journeys over fixed routes (2).

In addition to dog tickets, the P.O. also issued special tickets for dog kennels (Fig. 1027).

This class of ticket is less widely used by road firms. Some however are used with drawings (Fig. 1030), and in England thin cardboard tickets (Fig. 1028).

Tickets for horses, etc. — Such transport is usually carried by express goods or passenger train. Illustrations are given of the following examples :

Collective ticket for race horses (Fig. *618*) ;
Ticket for a horse (Fig. 1032) ;
Ticket for a donkey (Fig. *160*).

There are a series of tickets issued in connection with hunting :

For a hunting horse (Fig. 1034) ;
For hunt meeting, *London & North Eastern Ry.* :
For a groom.

Other animals. — The issue of tickets for other animals is exceptional. It is interesting to note that if need be they often mention the animal to be carried — accompanied by a passenger. For example the *Gold Coast Ry.* tickets :

« For two fowls accompanied » (Fig. 1029).

Scale of tickets 4/5.

Fig. 1031. — Thin cardboard ticket for a dog, valid in either direction. — Overprinted with the category. — *Manchester Corporation Transport Department.*

Fig. 1032. — Ticket for a horse. — Distinctive marks relating to international traffic. — *Indo-China and Ynnan Rys.*

Fig. 1033. — Ticket for a dog or cat. — Fixed rate from the departure station. — *South Eastern & Chatham Ry.*

(1) On the *L.S.W.Ry.* such tickets were white with two green margins down the long sides. Two vertical red lines in the middle meant transport over the Company's own lines, and two blue lines meant inter-railway transport.

(2) *P.O. Ry.* On the *Alsace-Lorraine Ry.* « combined » dog tickets are printed with a small drawing.

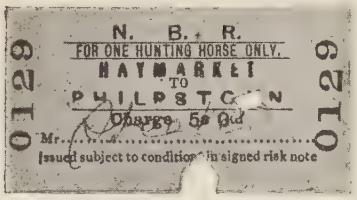


Fig. 1034. — Ticket for a hunting horse. — Name of the owner. — *North British Ry.* — (Scale 4/5.)

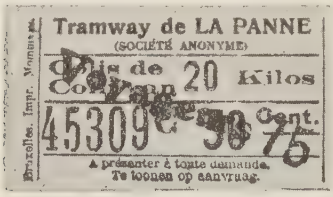


Fig. 1035. — Paper ticket for a parcel. — Overprinted to serve as a passenger ticket. — *La Panne Tramways.* (Scale 3/4.)

The *South Eastern & Chatham Ry.* had tickets for :

Dog or cat (Fig. 1033).

There are special tickets for cats in Turkey, small livestock in India, livestock in South America, and :

Sheep, goat, pig or dog in Kenya.

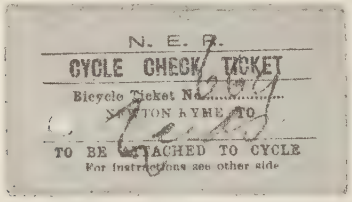
B. — Transport of things.

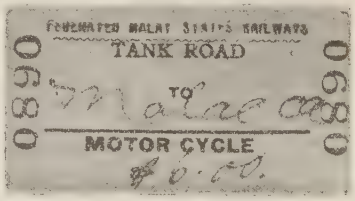
Corpses. — We include the transport of corpses under this heading.

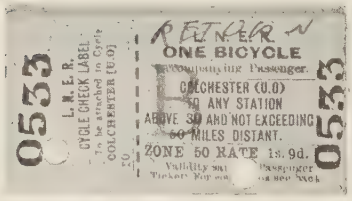
Several Companies issue paper tickets or even Edmonson tickets for this purpose. They are always single tickets.

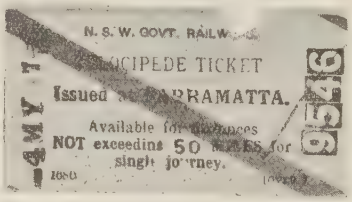
For the sake of completeness, we must mention tickets for members of a funeral cortege (Fig. *158*) and also tickets for coffins (fig. 1044).

Bicycles and similar objects (prams and mailcarts). — The transport of these









Bicycle tickets, etc. (Scale 4/5.)

Fig. 1036. — Ticket to be attached to a vehicle. — *North Eastern Ry.*

Fig. 1037. — Zonal ticket with coupon to be fastened to vehicle. — *London & North Eastern Ry.*

Fig. 1038. — Motorbicycle ticket. — *Malay Federated States Ry.*

Fig. 1039. — Zonal bicycle ticket. — *New South Wales Government Rys.*

things has led to the issue of special tickets, usually with zonal rates (Fig. *625*, with drawing).

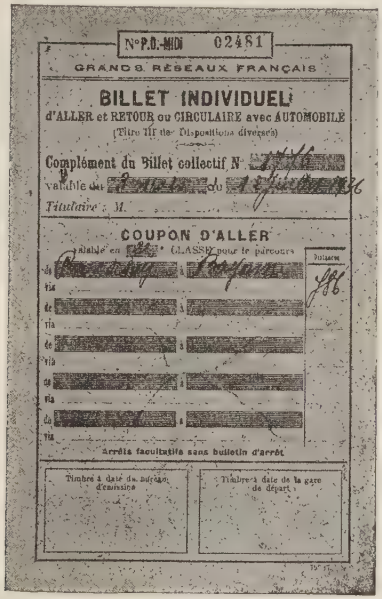

N° P.O.-MIDI 02481
GRANDS RÉSEAUX FRANÇAIS
BILLET INDIVIDUEL
d'ALLER et RETOUR ou CIRCULAIRE avec AUTOMOBILE
(Titre III des Dispositions diverses)
Complément du billet collectif N°
Titulaire : M.
COUPON D'ALLER
Arrêts facultatifs sans bulletin d'arrêt
Timbre à date de la gare d'arrivée
Timbre à date de la gare de départ

Fig. 1040/1041. — Coupon for outward journey, supplement to a collective ticket, for return journey by motor car. — *French Main Line Rys.* — *P.O.-Midi.*

It is specified that such objets accompany a passenger at his own risk and the validity is frequently « the same as that of the passenger ticket » (1). Special tickets are also issued corresponding to special passenger tickets, such as « day trip return », etc.

BICYCLES (2). — Certain English Companies have tickets with a detachable portion which is fastened to the bicycle itself (Fig. 1036).

As the rates are the same for bicycles and certain other objects, a single series of tickets is printed to cover them all :

Child's pram, mailcarts, etc. (1) ;

Tricycle or invalid chair, *Geneva Navigation Co.;*

Dog, pushchair or bicycle, *Geneva Navigation Co.;*

Child's pram, *Thun to Hilterfingen Ry.*

and the most universal of all on the *South Eastern & Chatham Ry.* :

Child's pram or mailcart, invalid chair, sewing machine or typewriter !

To profit by the reduced rates, the cost of the passenger ticket must sometimes reach a given minimum (3).

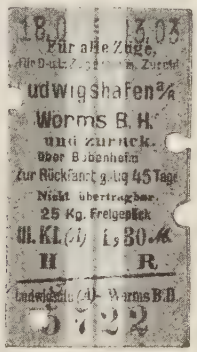


Fig. 1042. — Return ticket including free transport of luggage. — White band indicates return ticket. — Valid by all trains, as shown by vertical band. — *Bavarian State Rys.* (Scale 4/5.)

(1) *London & North Eastern Ry.*

(2) The terms « velo » and « velocipede » are also used (Fig. 1039).

(3) *Geneva Steam Navigation Co.* — Before 1914 « carried at 50 centimes if the passenger ticket cost at least 75 ».

Special tickets are also issued for other hand propelled vehicles :

« Hawker basket or push car »;

« Go car » or similar object, *L. & S. Western Ry.*

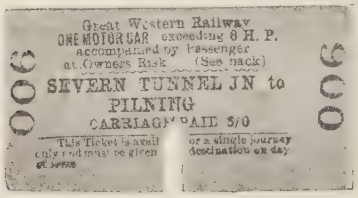

Great Western Railway
ONE MOTOR CAR exceeding 8 H. P.
accompanied by Passenger
at Owners Risk (See back)
SEVERN TUNNEL JN to
PILNING
CARRIAGE PAID 5/0
This Ticket is available only for the journey for which it is given
or a single journey destination on day
006
006

Fig. 1043. — Ticket for carrying a motorcar through a tunnel. — *Great Western Ry.* (Scale 4/5.)

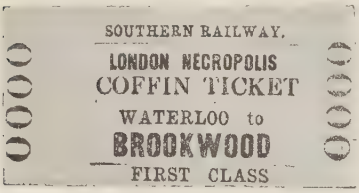


Fig. 1044. — Ticket for a coffin to London Necropolis. — *Southern Ry.* (Scale 4/5.)

There are also single, return and cheap tickets and seasons for depositing luggage or bicycles which we will not deal with here.

With the development of road vehicles, new tickets had to be issued if these were to be transported by rail, boat, or tender (1) :

Tickets for motorbicycles (Fig. 1038);

Tickets for motorcars.

There are also special tickets for the transport of motorcars by rail through long tunnels (Fig. 1043). Certain excursion tickets with detachable coupons allow passengers to take their cars with them without additional charge (Fig. 1040/41).

TICKETS FOR VARIOUS OBJECTS. — We will only mention the following :

Hand luggage;

Baskets (2);

Perishable goods (3);

Parcels;

Goods of a given weight accompanying a passenger;

Unaccompanied goods of a certain weight.

Certain tickets entitle the holder to free transport of a certain amount of luggage. This is then indicated on the ticket (Fig. 1042).

Many secondary railways and tramway companies issue tickets for luggage or parcels (4). These are issued for all fre-

---

(1) The *Southern Ry.* carries accompanied motorcars of a minimum length of 10 ft. and maximum of 14 ft. in its Yarmouth tenders. Cheap day tickets are issued for this purpose.

(2) *Isle of Wight Central Ry.*

(3) On the *South African Rys.* tickets are issued at half the zonal rates for parcels in the case of baskets of flowers and fruit. These must weigh between 26 and 50 lbs. The Company is not responsible. Tickets are printed in two languages.

(4) *At Birkenhead*, etc. The *Thames Valley Traction Co.* issues tickets of different values for the transport of accompanied luggage as well as parcels (31, 71, 141, 281, 421 & 561 lbs.). There are also tickets for parcels of newspapers weighing not more than 201, 301 or 401 lbs.

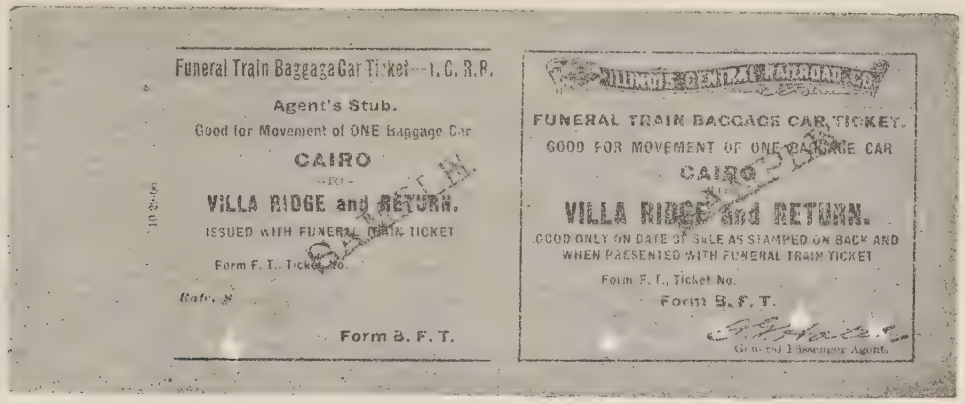

Funeral Train Baggage Car Ticket — I. C. R. R.
Agent's Stub.
Good for Movement of ONE Baggage Car
CAIRO
— to —
VILLA RIDGE and RETURN.
ISSUED WITH FUNERAL TRAIN TICKET
Form F. T. Ticket No.
Date, 19
Form B. F. T.
ILLINOIS CENTRAL RAILROAD CO.
FUNERAL TRAIN BAGGAGE CAR TICKET.
GOOD FOR MOVEMENT OF ONE BAGGAGE CAR
CAIRO
VILLA RIDGE and RETURN.
GOOD ONLY ON DATE OF SALE AS STAMPED ON BACK AND WHEN PRESENTED WITH FUNERAL TRAIN TICKET
Form F. T., Ticket No.
Form B. F. T.
General Passenger Agent.

Fig. 1045. — Ticket for a funeral car. — *Illinois Central R.R. Co.* (Scale 3/4.)

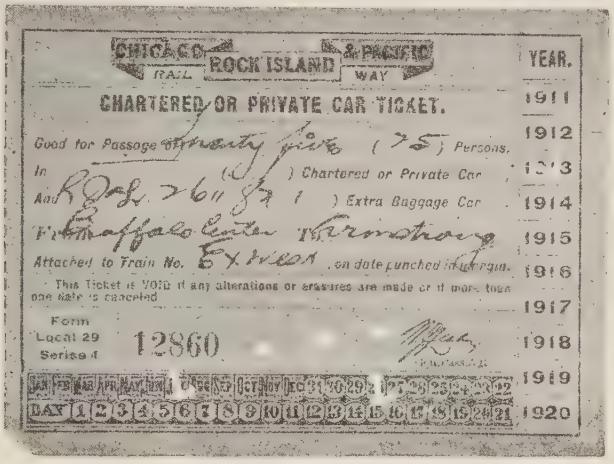


Fig. 1046. — Ticket for chartered or private car. — Lists of days, months and year. — *Chicago Rock Island & Pacific Ry.* (Scale 3/4.)

quent consignments of a special nature, differentiated according to whether they are accompanied or not. It is interesting to note that owing to a lack of tickets, passengers may travel on « parcel » tickets.

Special tickets are also issued for the transport of milk (1), and again for

(1) The *Illinois Traction Co.* uses duplex tickets for this purpose. A figure corresponding to 5, 8 or 10 gallons of milk is perforated. Two perforations are needed to indicate the distance in 5 mile stages up to 95 miles (8 to 8 km. up to 152 km.), and if needs be an additional perforation indicates the hundreds.

sports equipment travelling with its owner : skis, bobsleighs (Fig. *939*), fishing nets. We have mentioned these when dealing with sports tickets.

Tickets are issued for the container (Fig. 1027) as well as tickets for the contents : tickets for kennels as well as tickets for dogs; tickets for coffins as well as those for corpses (Fig. 1044). The *Southern Ry.* issues pre-printed tickets between London and Brookwood cemetery, though paper tickets are generally used.

Customs tickets. — Customs formalities take place on a certain number of through trains, and in particular on sleeping car trains. The *International Sleeping Car Co.* has issued special tickets for :

Frontier tax for registered luggage;
Custom dues.

Tickets for reserving railway carriages. — Paper tickets of this sort are sometimes printed in advance. They are issued for :

Funeral car (Fig. 1045);
Hired or private car (Fig. 1046).

C. — Tolls.

Such tickets are issued to those walking or riding over the Company's property. They allow foot passengers :

onto a station or platform (1) (Figs. *29.2*, 1047 and 1048);
over a bridge (2);
to land (3) (Fig. 1049).

The latter (English landing tickets) also generally include the harbour dues.

In addition to collect funds for charitable objects, authorisation is sometimes given on special occasions to visit certain shops or works to which the public is not normally admitted, and special tickets are issued for this purpose. The visit to the Mersey Tunnel (4), access to a

---

(1) *London Passenger Transport Board.* « Earl's Court Station from Warwick Road to Earl's Court Road or vice versa. Toll 1 d. »

As the successor of the *District Ry.* the *L.P.T.B.* also issues tickets to and from Bow Street Station for 1 d.

(2) Bournemouth Foot Bridge. — Weekly ticket 6 d.

Bournemouth Corporation Truckton Bridge 1/2 d. toll.

Burma Ry. Bridge at Ava. — One foot passenger 6 pies.

Suddeutsche Eisenbahn Ges. — Bridge toll : 5 pf.

Such tolls also exist in the U.S.A. The *St. Louis & East St. Louis* issues books of coupons; the *Terminal R.R. Association of St. Louis* issues books of 62 coupons valid for one month during one of the ten years listed on the book.

(3) Plymouth Dock tolls : 1 1/2 d. per person; 1/— toll for a passenger and his luggage.
Portishead Pier. — Admission : 1d.; embarking and landing : 2 d.

Jersey Poll tax. — For one boat : 2 d.

Weymouth Quay. — Landing and transport : 1/3 d.

Brading Harbour, Isle of Wight *(Southern Ry.)*. — « Embankment Road & Works ». — Received for one of the 6 d. tolls enumerated in the list of authorised tolls.

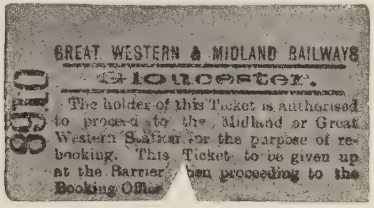
(4) Authorisation to cross the tunnel on foot between 30th March and 2nd April 1934. Receipts for the benefit of local hospitals.

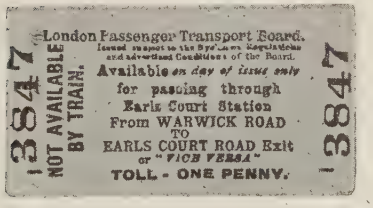
station in York to inspect railway rolling stock, etc.

Tolls are also imposed on pedestrians, vehicles and horses on roads :

« Two horses carriage and driver » (1) ;
« Horse and rider » (1) ;
Cattle, horses and mules, each (loose) or motorcycle parcel delivery (2).

The right to park cars on railway property is similar to the charges for which landing tickets are issued (3). A different case is the purchase of a ticket


GREAT WESTERN & MIDLAND RAILWAYS
GLOUCESTER.
The holder of this Ticket is authorised to proceed to the Midland or Great Western Station for the purpose of re-booking. This Ticket to be given up at the Barrier when proceeding to the Booking Office
8910



Ticket for passing through a station. (Scale 4/5.)

Fig. 1047. — Free token to allow holder to rebook. — *Great Western Ry. & Midland Ry.*

Fig. 1048. — Toll. — *London Passenger Transport Board.*

authorising the use of a level crossing and private roadway owned by a Company (4).

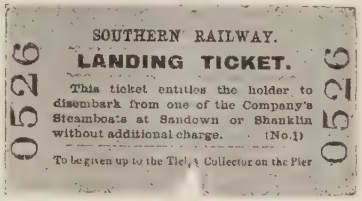

SOUTHERN RAILWAY.
LANDING TICKET.
This ticket entitles the holder to disembark from one of the Company's Steamboats at Sandown or Shanklin without additional charge. (No.1)
To be given up to the Ticket Collector on the Pier
0526
0526

Fig. 1049. — Landing ticket for the Isle of Wight. — *Southern Ry.* (Scale 4/5.)

Fig. 1050. — Ferryboat ticket. — *Great Western Ry.*

We have already stated that certain Companies increase their rates by a certain amount in order to meet the cost of building certain important structures. This is done by increasing the real distance by a certain number of miles or by adding a fixed temporary charge to the fare for each journey.

The lifts in use on certain stations are also a form of transport though not the same as railway transport. The use of

---

(1) *Pierre & Fort Pierre Bridge Ry. Co.*

(2) *Chicago Burlington & Quincy R.R. Co.*

(3) In Belgium, the price was fixed at 3 frs. On the *Great Western* and *Southern Rys.* it is now one shilling. Formerly 1 d. had to be paid for the right to park « cabs » in the London Terminus stations.

(4) *Southern Ry.* — At Bishopsgate the holder of a shilling ticket can pass through with a vehicle once in each direction. The same shilling entitles him to park his vehicle but at his own risk.

some of them is free (1); elsewhere tickets are issued on the lift (2) (Fig. 1051).

Fig. 1051. — Lift ticket. (Scale 4/5.) — *Great Central Ry.*

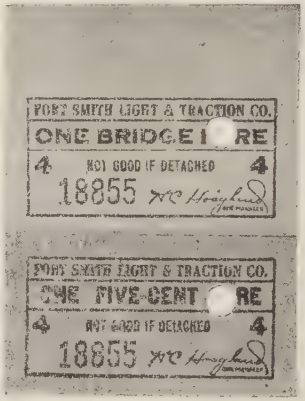
Finally each passenger must pay a toll to cross certain bridges, even when travelling in public transport vehicles. A special ticket is then issued to cover the toll, the whole amount being paid to the owner of the bridge or the amount less a fee for collecting it.

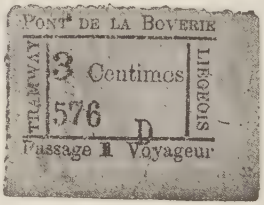
This system is used on the Golden Horn Bridge at Istambul.

In other cases the price of the ticket for the journey is increased by the amount of the toll. At Liége 3 centimes used to be charged for crossing the Boverie Bridge; this supplement was shown on the back of the ticket, and the fare for the journey on the face (Fig. 1053).

In the United States the tickets issued often consist of two portions, one relating to the journey and the other to the toll (Fig. *606*-1052).

A special ticket is often used when the journey includes a section of line belonging to another public or private transport company (3) (Fig. 1013).





Tickets for bridge tolls. (Scale 4/5.)
Fig. 1052. — Coupons for transport and the tolls. — *Fort Smith & Traction Co.*
Fig. 1053. — Back of an old ticket of the *Liége Tramways* showing the toll in fractions.

(1) London Underground.

(2) *Great Central Ry.* — Victoria Station, Sheffield, 1/2 d.
P.L.M. — Monte Carlo station lifts.
P.O.-Midi. — Biarritz lift ; Quai d'Orsay lift.
Portuguese Tramways. — Lisbon lifts.

(3) *Brussels Tramways.* — On the section built by the town of Brussels to give the trams access to the 1935 Exhibition.
Ghent Electric Tramways. — Special ticket for the St. Amand section owned by the *Belgian Light Rys.*
Paris. — Supplement for the Charenton (Ecoles). — Petit Charenton section. (These can be used if necessary as a supplementary ticket for a passenger changing from 2nd to 1st class.)

ADMISSION AND PLATFORM TICKETS. — At one time rarely used, their use has been extended from France to Germany, Belgium, Bulgaria, Italy, Austria, Hungary, and even to Egypt. At first they were only used in the principal stations. They are not much used in the United States, and have not yet been used in Switzerland, the Argentine nor Mexico.

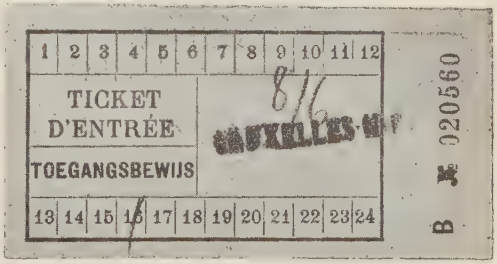
Holders of such tickets have no right to board trains and must not remain on the station more than a certain time, or must leave as soon as the train has gone (1). Such relations were important when there was no intercommunication between the coaches and a check during the journey was difficult. Now that conditions have changed it may be questioned whether platform tickets should be retained ? Everything which tends to lower the barrier between the railway and the public is to be recommended, as there is no such barrier in the case of road transport. For this reason the old practice of keeping passengers shut up in a waiting room until the time the train was due to leave was justly condemned.

Prior to 1914 the price of a platform ticket was 10 or 20 centimes. Several Railways had two different charges according to whether the station was classified as first or second class.

The maximum validity of platform tickets is two hours. Originally however some of them had a shorter validity (2).

The hours of the day are shown on most of these tickets. The old paper tickets were only sold at certain hours of the day. In France only the hours

6 7 8 9 10 11 12 1 2 3 4 5
TROYES
TICKET D'ENTRÉE DANS LA GARE
Il est formellement interdit au porteur de ce billet de monter dans les voitures
10 Centimes
A 51920



Paper entry tickets. (Scale 3/4.)

Fig. 1054. — One of the first French tickets, detached from a block. — Hours from 6 a.m. to 5 p.m. — Name of the Company, *Est*, overprinted in red.

Fig. 1055. — Makeshift ticket used after 1918. — Usable all round the clock. — *Belgian State Rys.*

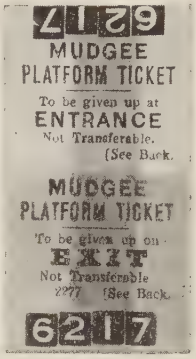
---

(1) *Burma Rys.* — « Current up to the time of departure of the train in connection with which it is issued. »

(2) 20 minutes only for tickets issued to passengers from the *Ceinture* to platforms in the Sceaux-Ceinture station.

Similar phrasing is used on certain British tickets « Pass bearer to platform » (*Ceylon Govt. Rys.*, 5 cents) in place of the usual platform ticket.

between 6 a.m. and 5 p.m. were shown (Fig. 1054. Later on the hours were printed from 1 to 12 twice, those relating to the night being shaded or printed in red [1] (Figs. *123-479*). At the present time all the hours from 1 to 24 are shown ar-

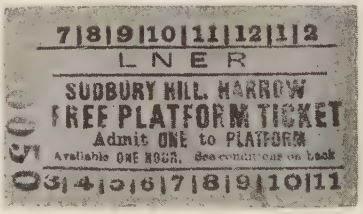


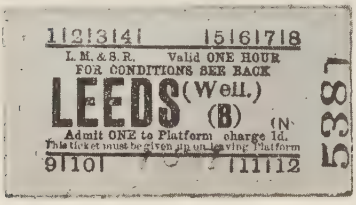
Entry tickets. (Scale 4/5.)

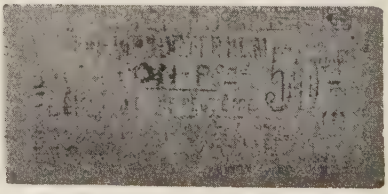
Fig. 1056. — The hours are shown on the back. — *Nord Ry.* — Issued by a machine.

Fig. 1057. — Entry ticket in two parts one of which is collected on entering the platform and the other on leaving. — Not transferable. — *New South Wales Government Rys.*

Fig. 1058. — Makeshift ticket printed on the back of another ticket. — Text printed obliquely. — *West Australian Govt. Rys.*







Entry tickets. (Scale 4/5.)

Fig. 1059. — The hour of issue written in by hand on space provided. — Montjoie Line, *Belgian National Rys.* — German pattern.

Fig. 1060. — English ticket with groups of hours. — *L.M.S.Ry.*

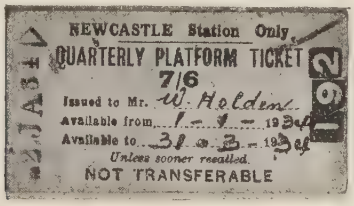
Thin cardboard entry tickets. (Scale 4/5.)

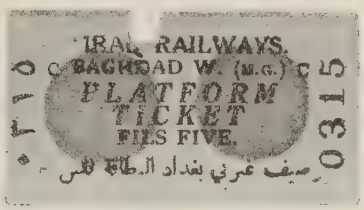
Fig. 1061. — Showing hours from 7 a.m. to 11 p.m. — *London & North Eastern Ry.*

Fig. 1062. — Ticket printed by an automatic machine. — *P.L.M. Ry.* — Very badly printed.

[1] *London Midland & Scottish Railway.*

ranged in various ways : in Rome for example they are printed in four columns, and in Aachen in pairs. On the Montjoie line blank tickets are used, the hour of issue being written in by hand (Fig. 1059). For control purposes it is only necessary to perforate the hour the holder went on to the platform.





Entry tickets. (Scale 4/5.)

Fig. 1063. — Quarterly platform ticket. — *London & North Eastern Ry.*

Fig. 1064. — Ticket printed in two languages with distinctive marks. — *Iraq Ry.*

The first platform tickets were paper tickets; they were made up in blocks of one hundred. This system was reintroduced in Belgium after 1918 (Fig. 1055). Cardboard Edmonson tickets were soon substituted however, with the name or number of the issuing station and the designation « Billet de quai », « Entrance ticket » (in Belgium), « Billet de perron » (in Holland), « ticket giving access to platform » and recently « Platform ticket » in France. As far as we know the *Nord Railway* is the only Company to use tickets larger than standard (1); these used to be octagonal (Figs. *122-123*) and are now rectangular (Fig. 1056).

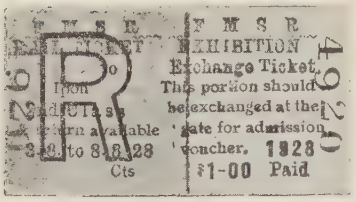
Platform tickets were the first tickets to be issued mechanically in the stations, so they were designed to meet the mechanical requirements of the ticket machines. This is why thin cardboard tickets are used in the English stations (Fig. *478*), some of which come off rolls and so are specially perforated (Fig. *477*), and it also explains the use of various shapes of tickets (Fig. *121-595*).

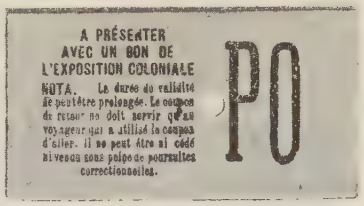
Many of the machines print the tickets on thin cardboard at the time of issue (Fig. *661*). The first such machines, some of which are still in use unfortunately, only issued tickets of mediocre quality, some of them completely illegible (Fig. 1062).

To distinguish platform tickets from ordinary tickets, they were at first printed with special marks or had coloured margins (Fig. *121*); various colours were used, and some of them were two coloured. This practice has been given up and now the name or number of the issuing station is merely printed in large letters, and this together with the colour of the ticket and the arrangement of the text is sufficient to distinguish them. In England, however, they are sometimes printed in red or in two colours, with just the name of the issuing station in red.

Some platform tickets are in two parts like return tickets. One part is collected

(1) Whereas the standard tickets measure 30.5 by 57 mm. (1 3/16″ × 2 1/4″), i.e. 1 738.5 mm² (2.635 sq. in.), these are 40 by 58 mm. (1 37/64″ × 2 9/32″), i.e. 2 320 mm² (3.565 sq. in.). Standard sized tickets are therefore only three quarter the size of the latter.





Exhibition tickets. (Scale 4/5.)

Fig. 1065. — Ticket with two portions, one for the journey, the other to be exchanged for an entry ticket for the exhibition. — *Malay Federated State Rys.*

Fig. 1066. — Ticket allowing free entry if accompanied by a voucher for the Colonial Exhibition. — *Paris-Orléans Ry.*

when the holder goes on to the platform, and the other when he leaves it (Fig. 1057).

Several Companies issue or used to issue season platform tickets for 1, 3, 6 or 12 months, which at first could only be used once a day, but latterly as often

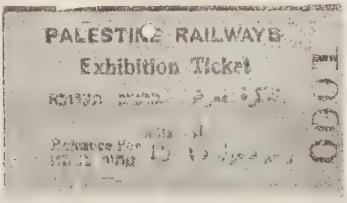


Fig. 1067. — Exhibition ticket in three languages. — *Palestine Rys.* (Scale 4/5.)

as the holder wished (Fig. 1064). In Italy books of tickets are sold of 20, 40 or 80 tickets, the price of which varies according to whether the station ranks as 1st or 2nd class.

Free tickets or seasons are also issued to the press, officials of certain departments, and other persons whose duties necessitate their frequent presence on the station : hotel and agency employees, messenger boys and welfare workers.

D. — Ancillary services.

In order to encourage the public to travel, the Companies issue tickets which not only cover the actual journey but also certain services which have nothing to do with the railway. In such cases the ticket consists of a series of coupons, some of which are valid for the rail journey and the remainder for other services. When Edmonson tickets are used for this purpose they consist of three parts, while paper tickets and cards are made up of detachable coupons or sheets. We give certain examples of such tickets below.

Tickets which include admission to an Exhibition are relatively frequent [1] (Figs. 1065 to 1067), as well as those with a coupon giving access to a show [2] (Figure *179* shows a ticket the lower part of which entitled the holder to a seat in a cinema).

---

[1] Exhibition in Halifax, Canada; Paris (Fig. 1066).

[2] The *Federated Malay State Rys.* issued tickets for Ripon, one part of which (the blue) was for the rail journey, and the other part (the red) to be exchanged for an « admission voucher ».

Additional coupon giving access to a theatre (*Florence*, 1880).

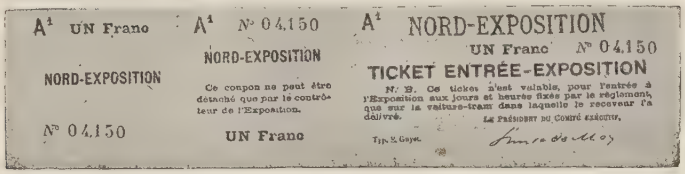
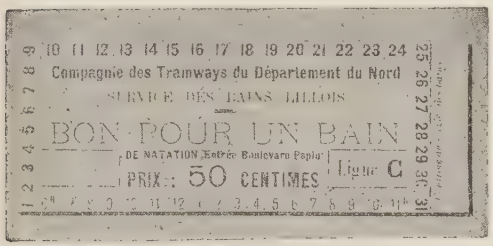

A¹ UN Franc
NORD-EXPOSITION
N° 04.150
A¹ N° 04.150
NORD-EXPOSITION
Ce coupon ne peut être détaché que par le contrôleur de l'Exposition.
UN Franc
A¹ NORD-EXPOSITION
UN Franc N° 04.150
TICKET ENTRÉE-EXPOSITION
N. B. Ce ticket n'est valable, pour l'entrée à l'Exposition aux jours et heures fixés par le règlement, que sur la voiture-tram dans laquelle le receveur l'a délivré.
Le Président du Comité exécutif.
Typ. S. Goyer.

Fig. 1068. — Entrance ticket to Exhibition, in thin cardboard, issued in a coach of the Gare du Nord. — Exhibition line in 1898. — *Brussels Tramways.* (Scale 1/2.)


Compagnie des Tramways du Département du Nord
SERVICE DES BAINS LILLOIS
BON POUR UN BAIN
DE NATATION Entrée Boulevard Papin
PRIX : 50 CENTIMES
Ligne C

Tickets for ancillary services. (Scale 1/2.)

Fig. 1069. — Thin cardboard ticket with three portions, two for the journey there and back and one giving entry to the Paris Exhibition in 1937. — *Metropolitain Ry.*

Fig. 1070. — Good for a bath. — *North Tramway Co. Lille,* 1880.

The *London Brighton & South Coast Ry.* issued many tickets giving access to the Crystal Palace. They also introduced both for their own and the lines of other Companies linked up with theirs « one shilling Day » tickets to attract the public.

Sometimes the Companies issue a special ticket which can be exchanged for a token (¹).

Road transport firms grant such facilities even more often than the railways. Tickets giving entry to exhibitions have been used since the Brussels exhibition in 1897 when the tramway company running into the exhibition grounds sold supplementary tickets for this route (Fig. 1068).

Tickets including a coupon for shows or baths were generally return tickets. Here are some examples :

Supplementary coupon for a theatre (²) ;

« Admission to Entertainment » *Rothesay ;*

Admission to the Zoological Gardens (Dieppe-Sières) ;

Swimming bath tickets (³) (Figs. 854-1070) ;

Beach services (Fig. 1073).

Excursion tickets often entitled the holder to a meal on the journey. Fig.

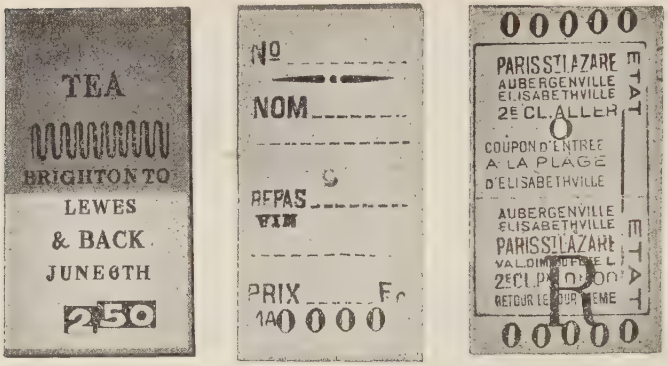
(¹) The golf tickets of the *Belfast & County Down Ry.* must be exchanged at the Club House.

(²) *Florence,* 1880; the *Brescia-Manutau-Ostiglia Tramway* issues them for many theatres.

(³) *Naples-Nola-Baiano Ry.*

The *Lagunare Soc.* of the Lido.

The first tramway services in Lille also issued tickets « Good for a bath » in addition to transport tickets (Fig. 1070).



Edmonson tickets. (Scale 4/5.)

Fig. 1071. — Return ticket with coupon for tea. — *London Brighton & South Coast Ry.*

Fig. 1072. — Ticket entitling holder to a meal at a reduced rate in the Charleroi canteen. — With holder's name. — *Belgian State Rys.*

Fig. 1073. — Ticket in three portions, two for the outward and return journeys and the third giving admission to the beach. — *French State Rys.*

NEWFOUNDLAND RAILWAY
BUFFETT CAR SERVICE.
TRAINMAN'S TICKET.
ONE MEAL - - 25 CENTS
PLEASE PAY WAITER.
The holder of this ticket will please fill up the Blanks on back hereof, and pay the amount above named to Waiter of Buffett Car.
Form 141.
44040

Fig. 1074. — Ticket for a meal in a buffet car. — Category : train staff. — *Newfoundland Ry.* (Scale 2/3.)

1071 shows one of the first tickets to include a coupon for this purpose [1].

Several Companies have special tickets for some of their canteens (Fig. 1072) or for the train staff (Fig. 1074).

Some Companies issued tickets which could be exchanged for a « snackbox » (Fig. *288*).

Tickets could include coupons for the most unlikely objects. The *P.O.* issued one, one coupon of which could be exchanged for a pair of gloves !

Such special services did not always involve the surrender of one of the coupons of which the ticket was made up. The Railway Companies often issued special tickets for such ancillary services; and urban transport services did likewise. We have already mentioned the tickets « good for a bath » issued by the former *Tramways du Departement du Nord* (Lille district), and the entrance to the 1897 Exhibition of the *Brussels Tramways* (Figs. 1068 and 1070).

Finally the Companies sometimes run

[1] Here is an example. The *Great Northern Ry.* of Ireland at the beginning of the century issued return tickets consisting of three coupons, the two outer ones, each 22 mm. (7/8″) long being valid on the tramway and railway (3rd class), one on the outward and the other on the return journey, and the centre coupon entitling the holder to a meat tea.

a service to provide bedding. In Irak Edmonson tickets are used for this purpose; elsewhere paper tickets are used. In Europe the only service of this kind is the hire of pillows, also by ticket *(Mitropa)*.

E. — Various services.

In addition to the tickets with which we have dealt in this Chapter, the Companies issue many tickets which of themselves do not entitle the holder to any form of transport. We have dealt with these in the preceding pages and will only recapitulate them here for the sake of completeness :

Tickets issued for pecuniary motives :

Tokens (Figs. *408-409*) ;
Stamps (Fig. *405*) ;
Receipt for change (Fig. *419*).

Various charges :

Taxes (Figs. *417-424*) ;
Insurance (Figs. *415-421*) ;
Refunds (Fig. *856*).

Justifications for reduced fares :

Requisitions (Fig. *410*) ;
Identity cards.

Control :

Tokens of all kinds;
Stopping tickets (Fig. *488-489*) ;
Train control (Fig. *491*) ;
Control sheets (Fig. *506*) ;
Duplicate tickets to replace lost tickets (Sweden).

Statistics :

Pass over card (Fig. *454*) ;

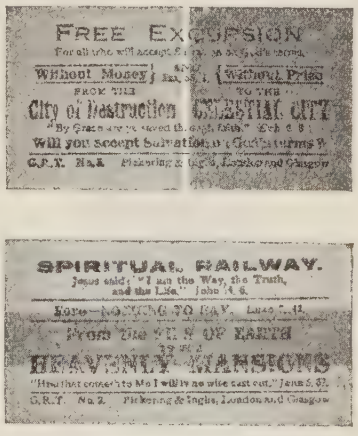
Special tickets for machines :

Test tickets (Fig. *686*) ;
Spare plate ticket (Fig. *687*) ;
Check tickets (Fig. *688*) ;

Tickets for special renumerations :

Coupon tickets for staff services *(International Sleeping Car Company)*.

Finally we may mention Edmonson tickets used entirely for publicity or propaganda purposes (Figs. 1075-1076), which are usually issued by private organisations, though certain Railway Companies have also used them.



SPIRITUAL RAILWAY.
Jesus said: "I am the Way, the Truth, and the Life." John 14. 6.
From the CITY OF EARTH
HEAVENLY MANSIONS
"He that cometh to Me I will in no wise cast out." John 6. 37.
G.R.T. No. 2.

Figs. 1075 & 1076. — Religious propaganda in the form of single and return tickets. (Scale 4/5.)

APPENDIX.

Control.

As operating methods improve, so control methods are perfected, and this leads to the introduction of new categories of tickets.

Serial numbers are generally used, and certain Companies, such as the *Arica to La Paz Ry.* make use of seven figure numbers, which is exaggerated.

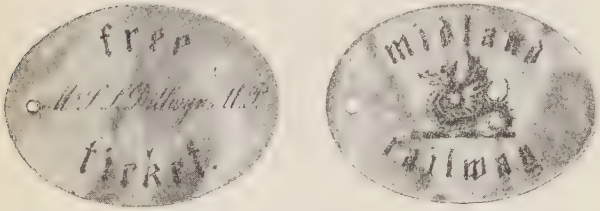


Fig. 1077. — Free pass for a member af Parliament. Made of mother of pearl. — *Midland Ry.* England. (Full size.)

Metal tokens. (Full size.)

Fig. 1078. — Free pass for customs officer. — *Marseilles Tramways.*

Figs. 1079-1080. — Token valid for short journeys. — *Budapest Municipality Tramways.* Back and front.

The use of WATERMARKED PAPER has spread even in Europe, where the *Belgian National Railways* and *Swiss Federal Railways* have made use of it in their books of detachable coupons.

FERN-VERKEHR DER STADT FRANKFURT A.M.
16 STRASSENBAHN-LINIE NACH OFFENBACH A.M.
24 TAUNUSBAHN HOHEMARK 25 TAUNUSBAHN BAD HOMBURG
F VORORT-OMNIBUS-LINIE NACH FECHENHEIM A.M.
VORORT-OMNIBUS-LINIE NACH BAD VILBEL
VORORT-OMNIBUS-LINIEN NACH HÖCHST A.M.
WALDBAHN NACH N.-ISENBURG
WALDBAHN NACH SCHWANHEIM

Fig. 1081. — Front of a suburban ticket issued in the town of Frankfurt on Main. (Scale 3/4.) — Graphical representation of the sections. — The line shown in white on black. — Issued by the *Frankfurt Omnibus Company.*

TO CONTROL THE ACCESS OF PASSENGERS to station hotels and buffets, some Companies issue special tokens when they enter such places in return for their tickets (Fig. 1082). The public are asked to co-operate with the staff and many Companies issue posters for this purpose (Fig. 1084). The *Dortmund Tramways* print rhymed precepts of this nature on the back of their tickets.

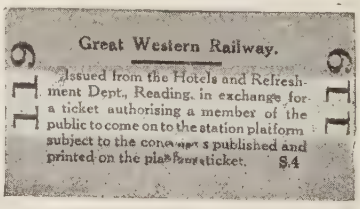

Great Western Railway.
Issued from the Hotels and Refreshment Dept., Reading, in exchange for a ticket authorising a member of the public to come on to the station platform subject to the conditions published and printed on the platform ticket.
$.4

Fig. 1082. — Token ticket giving access to the hotels and restaurant on the station. — *Great Western Ry.*

Finally in France tickets have been issued for station and control costs, both Edmonson tickets (Fig. 1083) and paper tickets which are inserted in the books of combined coupons. The price of these varies in zones of 100 km. (62 miles).

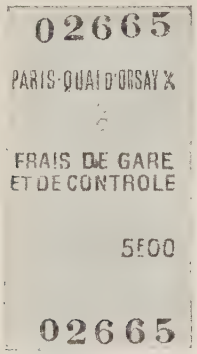


Fig. 1083. — Ticket for an additional tax known as « station and control expenses ». — *Sud-Ouest Region.*

CONTROL OF TICKETS AT THE BOOKING OFFICES. — We have described various ways of preventing tickets being removed from the middle of a pack, which would not be immediately discovered. Tickets in rolls or bands prevent this, but have certain drawbacks; tickets printed at the time of issue require the use of expensive machines. There are however simple methods of obtaining the same results.

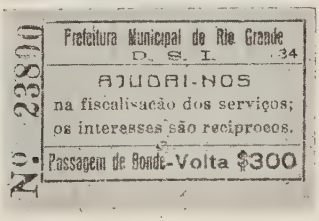
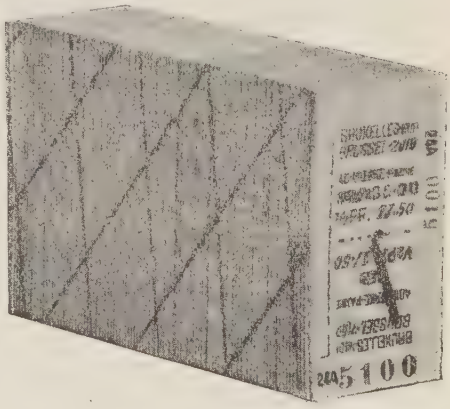


Fig. 1084. — « Fiscalisation » ticket explaining to passengers that their interests are reciprocal. — *Rio Grande Municipality,* Brazil. — (Scale 3/4.)

The Belgian system consist in making up the packets of tickets in a solid iron holder and printing a series of diagonal lines across the pack (Fig. 1085). If a ticket is missing from the middle of the pack it is at once apparent; futhermore as soon as they are put together again, it can be seen at a glance if the series is complete.



Control of the number of tickets.

Fig. 1085. — Belgian system. — Printing diagonal lines on the packet which is held together by an iron clip.

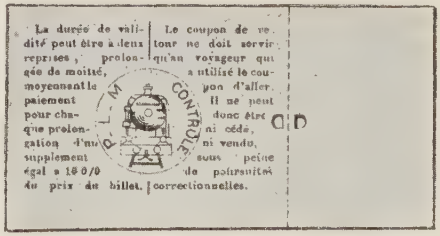

La durée de validité peut être à deux reprises, prolongée de moitié, moyennant le paiement pour chaque prolongation d'un supplement égal à 10 0/0 du prix du billet.
Le coupon de retour ne doit servir qu'au voyageur qui a utilisé le coupon d'aller. Il ne peut donc être ni cédé, ni vendu, sous peine de poursuites correctionnelles.
CONTROLE

Fig. 1086. — Double perforation system. — Back of a *P.L.M.* ticket (full size). — Return coupon. — Guarantee seal stamped on. — Text arranged to fit in with this.

The French double perforation method of packing as used on the *South-East and South-West lines,* is more ingenious (Figs. 1086 to 1088). The middle of each ticket is perforated by two holes one

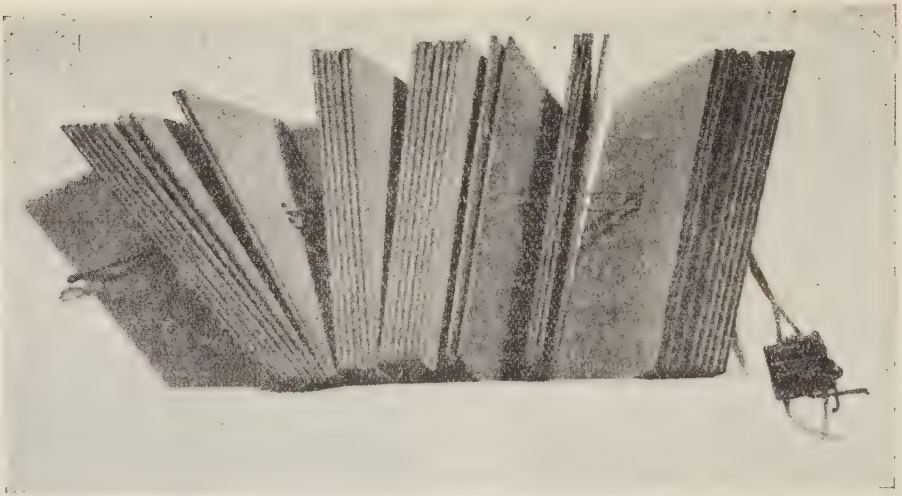


Fig. 1087. — Double perforation system. — Packet of tickets showing the fastening cords and seal

millimetre apart. A cord is passed through the upper half of the pack through one of the holes in each ticket then into a seal and back through the other hole; the two ends of the cord pass through a lead ring and are sealed with a control seal. This method of packing makes it possible to keep the packets of tickets in the booking office pigeon holes with the lead seal intact until the last ticket has been issued, so that no ticket can be sold out of turn. Naturally the lower seal which is only used to complete the packing is removed before the packet is put in the pigeon hole.

Fig. 1088. — Double perforation system. — Packet of tickets showing how the cord passes through the packet and is sealed. — Stamped with safety seal.

FINAL REMARKS.

In ending this series of articles, the fact should be stressed that the use of standard Edmonson tickets has been considerably extended. Such tickets are used almost exclusively in Great Britain, and form by far and away the major part of all tickets used by the railways of Europe, South America, Asia and Oceania. They are also used in North America wherever there is a large output.

The other methods reported are concerned above all with special tickets.

As we have seen there is greater variety in the case of the tickets used by secondary railways and tramway services.

[725 .32 (.73)]

Large concrete building takes a trip.

(Railway Engineering and Maintenance, December 1946.)

Powered only by three winches mounted separately on trucks, a large two-story, reinforced concrete store-and-office building of the Southern Pacific Company at Phoenix, Ariz., was moved recently a total distance of nearly 250 ft. The building, with a vault, was blocked up on metal plates over steel rollers, was severed from its original foundation, and was pushed over lines of rails in two different directions to rest over footings previously prepared for it at its new location. During the entire course of the work, telephone and lighting facilities were maintained and the employees carried on their duties within the building without being aware of any motion of the structure.

The lines of rails and blocking in position for the initial movement

This work was necessitated by a large increase in the number of cars handled by the Southern Pacific at Phoenix, which, in turn, called for the expansion of the existing yard at that point. To permit the construction of five additional tracks, it was necessary to relocate several units of fixed proprety about 180 ft. south of their present locations, included among which was the two-story store-and-office building, 66 ft. by 145 ft. and 30 ft. high, having a basement and vault. This building, which lay in a general east and west direction, was supported on 54 reinforced concrete columns, with six lines in an east and west direction and nine lines in a north and south direction, the various columns extending down to footing below the basement floor, six feet below ground level.

It was decided to dispense with the basement in the relocated building, and to raise the structure 9 3/8 in. higher

Showing part of the roller assemblies about one of the columns before it was cut off.

than in its original location. The new site selected for the building lay 72.2 ft. east and 177 ft. south of the original location, and plans were made to move it by making two right-angle movements, first eastward and then southward.

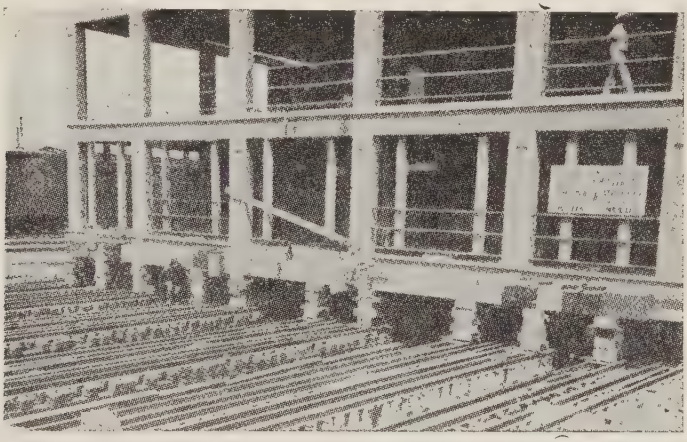
Preliminary work.

To clear the new site and construct footing to receive the building, it was necessary first to relocate a salt tank and to move a 100-ft. by 175-ft. oil sump approximately 200 ft. to the south. Furthermore, a considerable amount of preliminary work had to be done directly at the building itself before actual movement could begin. This included the removal of concrete curtain walls between the exterior columns ; the laying of several double lines of 75-lb. tee rail on wood blocking to serve as a runway for rollers ; the mounting of metal roller plates over the steel rollers ; the blocking of an 8-ft. by 16-ft. vault and the 54 columns of the structure on the roller plates ; the removal of an elevator from the building ; and the

Three winch-equipped trucks, securely blocked and anchored to deadmen, furnished the power to move the building. Jacks gave the initial impetus.

separating of the building from its foundation.

The concrete curtain walls between the exterior columns were cut out to lighten the weight of the building. At the same time, temporary posts of Oregon pine, 8 in. by 8 in., were placed on each side of the columns between first and second floor levels as a precautionary measure. Following this, preparations were begun for the eastward movement by leveling off the ground area east of the building and placing the roller runway. In building the latter, cribbing blocks were placed in lines parallel with the six lines of building columns, and were extended back within the basement, to support strings of 75-lb. tee



The pulling cables were fastened to heavy timbers attached to the rear of the building, thereby moving it by a pushing motion.

The new site was graded and footings were built in advance for the building.

rails. This involved some 10 000 pieces of 6-in. by 8-in. by 4-ft. long blocks of Oregon pine laid in 18 parallel lines, the placing of which required careful attention to assure the support of all runway rails on an even transverse plane.

Two lines of rails, spaced approximately two feet apart, were laid along each ble lines, of runway rails were laid and 100 shoes placed under the building, including those under the vault and end walls.

The movers then cut all columns and the vault and side walls, taking out sections in each case extending from the top of rail to an elevation about two feet below the column corbels, thus

The building at the end of the eastward movement, with the lines of rails and blocking in position for the next move at right angles. Note the temporary gap across roadway for vehicular traffic while the movement was under way.

of the six column lines, with one line on each side of the columns and with the top of the rails 3 ft. 10 in. below the first floor level. Additional lines of rail were laid in pairs to support the vault and the end walls. Rollers of steel shafting, 1 7/8 in. in diameter and 30 in. long, were then assembled on the rails in groups of eight under the concrete girders on each side of the columns. Following this, a roller plate, 16 in. wide, 48 in. long and 1/4 in. thick, was placed over each group of rollers and timber blocking was installed on top of the various plates to transfer the building load to them when the columns were severed. In all, 18 dou- transferring the building load of more than 2 000 tons to the roller assemblies, and the structure was then ready for its eastward movement.

Moving the Structure.

Prior to the severance of the building from its foundation, three motor trucks equipped with winches were located a short distance to the east of the rail runways and were securely blocked and lashed with steel cables to deadmen placed ahead of and behing them. Wire rope tackle, connected to the winches, was then carried under the building to its west end and was attached to 16-in. by

18-in. Oregon fir timbers fastened behind the structure. Through this arrangement, the building was pushed rather than pulled in its movement along the runway.

The winches were set in motion on June 5, 1946, at 8.38 a.m., and, with two hydraulic jacks furnishing the initial impetus, the building began to move. This movement commenced so easily, and its continuation was so gradual, that employees in the office of the building failed to take notice of it. The raising of the building to the higher elevation, previously mentioned, was accomplished by giving a suitable gradient to the rail runways provided for the eastward movement. The work continued throughout the day and despite numerous stops made to adjust the rollers and tackle, the building had been moved the required 72.2 ft. to the east by 4.55 p.m., in slightly more than seven working hours.

Upon completion of the eastward move, the building remained at that point until July 10, while the lines of rails and cribbing were changed to provide for the movement of 177 ft. to the south at right angles to the initial movement. These changes involved the laying of 21 lines of blocking and a similar number of double lines of supporting rails ; the more arduous task of turning the shoes and rollers for the southward movement ; the relocation of the « pusher » timbers from the west to the north side of the building ; and the re-stringing of the wire-rope tackle to the re-spotted and anchored winch trucks. A temporary gap was left in the lines of rails and blocking across a road that intersected the southward movement, to permit the unobstructed flow of traffic.

The north side of the building during its southward move. Part of the old foundation and some of the cut-off columns may be seen in the left foreground.

The southward movement.

The structure was started on its move southward on July 10, when it was moved 41 ft. to the edge of the road. The next day the gap in the lines of rails and blocking was closed and the building was moved 117 ft. farther south. On July 12, by 9.45 a.m., the building was moved 19 ft. to its final location, resting on cribbing, directly over the previously prepared footings.

The next step was the construction of new sections of reinforced concrete columns and walls between the new footings and the stubs of the original columns and walls left pendant below the first floor. The new column footings had been made 5-ft. 6-in. square and 1ft. 3-in. thick, with a key slot in the top of each to supplement reinforcing bars which were carried up into the new column area. The new column sections were made 2-ft. 4-in. square, and were carried up to enclose about 1 ft. of the bottoms of the stubbed columns. New reinforced concrete wall sections were likewise built between the footings and the pendant vault and side walls.

Building not damaged.

The concrete was allowed to set for 18 days and the cribbing, rails, and rollers were removed from under the building through three openings left in the new side walls. After the building rested on its new foundation, a careful instrument check and close examination of the structure showed that it had been moved without damage of any kind.

The project was under the general direction of E.E. Mayo, chief engineer of the Southern Pacific Company, and under the supervision of the road's Tucson division forces; G. A. Bays, division superintendent, and T. W. Saul, division engineer, with Gus Schneider, assistant engineer, in charge of field operations. The work of moving the building and setting it at its new location was performed, under general contract, by the Star House Movers, Los Angeles, Cal.

NEW BOOKS AND PUBLICATIONS.

[656. (02]

DE GROOTE (Paul), Professor at Brussels Free University. — **Traité d'exploitation des transports.** L'économie des transports. Les transports intérieurs. Les transports maritimes. — *(Treatise on the organisation of transport. The economics of transport. Inland transport. Maritime transport).* One volume ($6\,^{5}/_{16}$" × $9\,^{72}/_{32}$") of 400 pages and 20 figures. — 1946, Les Editions Comptables, Commerciales et Financières. Brussels, 47, rue du Houblon. (Price : 200 Belgian francs.)

It is possible to consider methods of transport solely from either a technical point of view or an economic point of view. The various works dealing with the organisation of transport, and in fact the teaching at the Universities usually come under one or other of these two aspects.

It is impossible to have a complete knowledge of the problem of transport whilst limiting oneself to an analysis of its economic elements. Certain facts will be imperfectly studied if a technical study is not made of special aspect in order to discover their origins. This will also enable the pure economists, or those whose tendencies lie in that direction, to make contact with the realities of technique, without overwhelming them with details which are only of interest to technicians. The latter will find in a perusal of this book a reminder of the fundamental function which their activities help to fulfil.

Before analysing in turn the characteristics of the organisation of all the various methods of transport, with the exception of air transport, the author studies in the first part of his work the nature of the function which the organisation of transport is called upon to play in the general economy.

From a subjective idea, generally inspired by a profit-seeking motive, is born a need for transport, which confronted with the possibilities which unfold gives rise to a definite demand for transport.

If this need for transport is considered from an individual point of view, it will be seen that it covers various elements : the goods to be transported, the route, the time of the transport, conditions such as speed, safety, and regularity, and finally the cost of transport.

On the other hand the need for transport has certain individual characteristics by which it differs from other economic needs, which are essentially as follows :

— its composite character ; to meet its requirements, a series of heterogeneous conditions must be met simultaneously ;

— its supplementary character ; it is an offspring of primary economic needs;

— its degree of intensity ;

— the elasticity of structure of needs for transport.

After explaining the principles upon which he has based the classification followed in his book, the author examines first of all transport without moveable parts or vehicles (electric power, gas, pipe lines), in which the displacement of fluids is brought about by the difference in tension, in potential or in pressure, if need be artificially created, from the place of production to the place of consumption. Such transport is worked in many cases by the producer, or else by distribution firms who undertake to make the necessary contact between the producer and the consumer. In any case the production and transport is concentrated between a small number of important undertakings. Their economic

function is enormous ; they may compete against the traditional methods of transport, or more rarely enable them to perfect their organisation. Finally they are limited in their extent.

This part of the book continues with a rapid review of the primitive methods of transport over land, by porters, pack animals, or caravans, which meet the requirements of small isolated currents of traffic which are not important enough for the traditional methods. The use of these methods tends to become more and more restricted.

As the evolution of overland transport led to the hauling of wheeled vehicles, over specially arranged roads, the author next deals with the resistance to inertia which is bound up with acceleration and the passive resistance of vehicles. The available impulsive power serves on the one hand to produce acceleration, and on the other to maintain the running speed thereafter.

The third part of the book is devoted to road transport, according to a definite plan, which is likewise followed in the case of railway and river transport : the track, the rolling stock, the statute authorising the transport, the organisation of the traffic, the cost price, and the cost to the public.

In their natural state, there are few roads which can be used without preliminary work. This work involves very complex problems. We are shown how to judge when it is opportune to link up two places by a road, how to select the route, and determine the type of road required. A special part is devoted to the special motor roads, which represent the results of systematic research to improve the running conditions of road vehicles.

After examining the various elements of the problem of the propulsion of motor vehicles, the author quotes the different sources of power available : petrol, or crude oil, showing in parallel tables the advantages and disadvantages of the internal combustion engine and the diesel, and finally alternative fuels. The importance of the choice of the unit capacity of the vehicle must not be lost of sight. The use of power units enable the unit capacity to be increased to the maximum, and lends itself to the specialisation of the functions of propulsion and transport. The intervention of the public authorities has a definite influence on the evolution of the motor vehicle.

The existence of small road firms is due to many reasons, the most important being the large amount of liberty of operation they are allowed. Restrictive legislation has lately come into force, as a result of the concern felt by Government Authorities over the problem of the co-ordination of road, rail, and water transport. The author stresses the fact that the private transport services are free to run as they please, and states his preference for a system of concessions based on wide general principles.

The movement of vehicles is so organised as to cover the places where there is the maximum possibility of getting a load ; it is regular when the traffic warrants it, or else irregular.

Owing to the lack of exact costs, the cost of road transport must be taken with caution. It is intrinsically high, greatly influenced by the amount of traffic, and the wages paid affect it very little. As to the selling price, the most usual system is individual quotations, not regular rates.

Railway transport is dealt with in the fourth part of the book.

The great value of the railway lies in the planitude of the rail and its low deformability. But the additional factors to which this subjects the movement of stock normally implies that the operation must be in a single hand.

The wide gauge has certain operating advantages, while the narrow gauge is cheaper to build and operate. Gradients add considerably to the cost of operat-

ing. To compare sections of line, they must be reduced to a common standard by the method of virtual length.

The layout of railway lines involves economic and technical study. To choose between the various possible alternatives, the financial cost must be determined and be related to the unit of transport, to enable an estimate to be made of the cost of operating the service.

A chapter is then devoted to the arrangement of the permanent way and the fixed installations. The track, which includes foundations, ballast, sleepers and rails, is submitted to various stresses, which are analysed in turn. The track equipment, which introduces an element of danger, should be reduced to the minimum. Special installations are required to assure contact with the public, and a whole series of buildings and work are to be found along the track to meet the various requirements of the traffic. The problem of the equipment needed to deal with goods traffic alone is dealt with in detail.

The characteristics of the rolling stock, goods wagons and passenger coaches, are then defined. The various kinds of motor units are dealt with in turn, first of all those which solved the problem of propulsion on rails by using thermal engines on wheels, then electric units. The value of electrification depends upon various factors, which are briefly reviewed.

The statutes of all railway undertakings have certain characteristics in common : considerable importance, industrial, social and financial nature, and close relations with the public authorities.

Except when the operation is undertaken by a ministerial department, the operation of a railway involves the granting of a concession. In the bye-laws under which the concession is granted will be found the conditions laid down by the public authorities which deal with the extent of the concession, the monopoly of operation, the intervention of the public authorities, the length of the concession, and the final regulations, the constant conditions under which the service is to be operated. There are differences of detail in the statutes, which may have great importance. The author makes a brief comparison between the statutes of the Belgian National Light Railways and the Belgian National Railway Company, and ends the chapter by several remarks on the operations of railways by the State ; he comes to the conclusion that there is little to choose between State railways and private undertakings, as regards efficiency and proper development of the rail transport services.

The organisation of the movement of vehicles on rails involves close collaboration between the traffic department, the traction and rolling stock department, and the permanent way and works department. The movement of the traffic is influenced by safety considerations : the main principles of signalling are dealt with, the problem of braking covered, and the method of spacing the trains analysed. The working of the traffic is then described (regular trains, special trains, dispatching).

Railway operating costs include a heavy percentage for the staff, which means a dead level in expenditure, and little adaptability to the variations in traffic. One form of adaptation is localisation. The analysis of railway costs and the use that can be made of such costs is commented on at length.

Railway rates are examined from the point of view of the function which they fulfil, the influence they exert upon the traffic, and their effect upon the nature of the traffic. The chapter ends with a report of the various goods rating systems, and the basic principles of passenger fares.

The part devoted to water transport begins with general considerations of the problem of inland navigation and the methods of propulsion used.

Inland waterways may be natural

riverways, not requiring any artificial extension, which are the best ; rivers adapted by various work ; rivers made into canals ; canals, which are the most artificial form of waterway. The latter complete an insufficiency of natural rivers or add to the system of navigable waters, and large capital sums must be invested in their construction. The economic value of a canal, its transversal and longitudinal profile are all elements involved in estimating the value of the work. To illustrate these points, the author deals in detail with the characteristics of the Albert Canal.

The next chapter begins with a technical summary : the structure of the boat, its resistance to stresses, floatability, and stability, and continues with an examination of the craft used on various types of waterways, ending with a study of the methods of propulsion when the boat leaves its anchorage, by cable or auto-propulsion (by hauling or motor tugs).

The three forms of operation which have developed are as follows : small boats plying for hire, merchant vessel undertakings, and transport services run in conjunction with certain industries. Liberty of movement is generally more or less complete.

An examination of the theoretical cost price is completed by a survey of the economic factors which affect the cost of navigation. Finally the price of the transport is generally arranged without official intervention, but freight charges and official dues mean that it closely approximates to the demand.

Though every method of transport can move any kind of goods, each one of them has certain characteristics, however, which lead in fact to a certain specialisation, though this is often rather vague and varies according to circumstances and place. Co-ordination, a function of the State, should tend to confine liberty of action within reasonable limits, to avoid abuses. The author gives the basic principles of a rational co-ordination of transport.

The seventh and last part of the book deals with maritime transport, the essential characteristics of which are stressed. After a few technical considerations regarding maritime ports, the economic function of the latter is dealt with at greater length ; the traffic, specialisation, equipment, port dues are all dealt with in turn. A special place is reserved in the next chapter for sea canals.

The stock used for navigation is examined from the double point of view of its form and methods of propulsion ; its characteristics are then reported.

Finally the author ends his treatise with a summary examination of the cost of maritime services, limited to the case of the transport of freight by sea.

[**621** .13 (09 .(42)]

NOCK (O. S.), B. Sc., D. I. C., A. M. Inst. C. E. M. I. Mech. E., A. I. Loco. E. — **The locomotives of Sir Nigel Gresley.** — One volume ($6\,^{5}/_{16}$" × $9\,^{1}/_{16}$") 182 pages, profusely illustrated. — 1946. London : The Railway Publishing Co. Ltd., 33 Tothill Street, S. W. 1. (Price : 10/6 d.)

This 180-page book, profusely illustrated, describes in detail the types of locomotives designed by Sir Nigel Gresley, firstly in his capacity as Locomotive Superintendent of the Great Northern Railway from 1911 to January, 1923, and then as Chief Mechanical Engineer of the London and North Eastern Railway up to the time of his death on the 5th. April, 1941.

The first locomotives built by Sir Nigel were the 0-6-0, 2-6-0 *(Mogul)* and 2-8-0 *(Consolidation)* types, all superheated.

In 1915 Sir Nigel interested himself in

the general tendency towards simple-expansion, multi-cylinder, superheated locomotives. In 1918, after several experiments, the first three-cylinder 2-8-0 appeared, with Walschaerts valve gear for the outside cylinders and a special gear for driving the piston of the middle cylinder.

Up to 1923 Gresley produced new 4-4-0 locomotives for express trains, 0-6-0 and 0-6-2 tanks and 2-8-0 locomotives.

Boiler pressures increased, as did their dimensions and the degree of superheating. Gresley sacrificed nothing to standardisation, for each type of service he built the most suitable locomotive.

He threw himself into the competition between British Railways for ever-faster and increasingly-powerful express locomotives. He saw the advantage of long-stroke valves, which he used on his 4-6-0 and 4-6-2 locomotives.

Meanwhile, he tried feed-water heaters, poppet valves and boosters.

In 1935 the new *Pacific* « Silver Link », with streamlined casing, appeared and reached a speed of 112½ m.p.h.

It was at this period that Gresley was knighted, in recognition — in the language of the Times — of his work as Engineer and Speeder-up of the *L.N.E.R.*

On the 27th. August, 1936, the *Pacific* « Silver Fox » reached 113 m.p.h., which still remains the British speed record for a train carrying fare-paying passengers.

The book contains numerous tables relating to the performance of Gresley locomotives on test runs. The tables give the route, specified and actual timings, speed, regulator opening, cut-off and boiler and steam-chest pressures.

Apart from all this very concise information, which is particularly valuable to those who know the gradients of the lines covered, there are very vivid descriptions of the trial runs at which the Author was present.

1947 621 .133 .7
FOX (B. D.).
Soft water for locomotive boiler feed.
London, Locomotive Publishing Company Ltd., 88, Horseferry Road, S.W.1. (Price: 10 s .net.)

1947 621 .133 .1
GRISWOLD (J.).
Fuel Combustion and Furnaces.
New York (U.S.A.), McGraw-Hill Book Company Inc., 330, West 42nd street. (Price : $ 5.50.)
London, McGraw-Hill Publishing Company Ltd., Oldwyck House, Oldwyck W.C.2. (Price: 27 s. 6 d.)

1947 621 .33
HINDE (D. W.) & INGHAM (H. E.).
Principles of direct current electric traction.
London, George Newnes Ltd. One volume, 248 pages, ($5^3/_4 \times 8^3/_4$ in.). Illustrated. (Price: 15 s.)

1947 621 .133 .1 (.42)
KIDNER (R. W.).
The development of the railway locomotive. 1880-1946.
Chislehurst, Kent, The Oakwood Press, 30 Whitehorse Hill. (Price: 6 s.)

1947 625 .17 (.73)
RENCH (W. F.).
Roadway and track.
New York, Simmons-Boardman Publishing Corporation, 30, Church Street. One volume of 350 pages, illustrated ($8^3/_4 \times 5^3/_4$ in.) Bound in cloth. (Price: $ 5.)

1947 621 .138
WEBSTER (H.).
Locomotive running shed practice : the maintenance and servicing of locomotives.
London, Oxford University Press (Geoffrey Cumberlege), Oman House, Warwick square, E.C.4. (Price: 18 s. net.)

1947 65
WEDGWOOD (R. L.).
International rail transport.
London, Oxford University Press, Oman House, E.
One volume, 162 pages ($8^1/_2 \times 5^1/_2$ in.). Bound in cl
(Price: 10 s. 9 d.)

In Spanish.

1947
CASADO (C. F.) & CASADO (J. L. F.).
Calculo de estructuras reticulares especiales por el todo de distribución de momentos.
Madrid, Editorial Dossat, S.A., Plaza de Santa Ana 1 vol., 84 paginas, 10 figuras, 35 lâminas. (Precio: 28 setas.)

1947 385
GARCIA-LOMAS Y COSIO (J.-M.).
Tratado de explotación de ferrocarriles. Tomo II: **material movil.**
Madrid, Publicacion de la Escuela especial de Ingeni de Caminos, Canales y Puertos. 1 tomo, en 4°, de 672 ginas con 533 figuras. (Precio: 140 pesetas.)

In Italian.

1946 69
STABILINI (L.).
Tecnica delle costruzioni.
Milano, Libreria Editrice Politecnica C. Tambu
1 volume, 811 pagine con 681 figure. (Prezzo: 1 100 li

[016. 385. (05]

II. — PERIODICALS.

In French.

Bulletin de la Société des Ingénieurs civils de France. (Paris.)

1946 625 .258
Bull. de la Soc. des Ing. Civils de France (mémoires), fasc. nos 9 à 11, septembre-octobre-novembre, p. 308.
ARMAND. — Position du **freinage électro-magnétique** dans le problème général du freinage sur le chemin de de fer. (2 000 mots.)

1946 625 .258
Bull. de la Soc. des Ing. Civils de France (mémoires), fasc. nos 9 à 11, septembre-octobre-novembre, p. 311.
ZOUCKERMANN (A.). — Le **frein électro-magnétique** sur rail et ses derniers progrès. (7 000 mots & fig.)

1946 621
Bull. de la Soc. des Ing. Civils de France (mémoir fasc. nos 9 à 11, septembre-octobre-novembre, p.
MERCIER (E.). — Le cycle équipression et la **turb à gaz.** (7 000 mots & fig.)

Bulletin des C. F. F. (Berne.)

1947 621 .33 (.4
Bulletin des C.F.F., mars, p. 38.
PASZKOWSKI (F.). — **L'électrification** en Suè (1 500 mots & fig.)

1947 659 (.4
Bulletin des C.F.F., avril, p. 50; mai, p. 66.
WANNER (F.). — Les Chemins de fer fédéraux **l'information.** (3 000 mots.)

1947 **385. (06 .4 (.494)**
ılletin des C.F.F., mai, p. 68; juin, p. 86.
Les **expositions du Centenaire** des C.F.F. (3 000 mo
fig.)

1947 **385. (09 (.492)**
ılletin des C.F.F., mai, p. 72.
REITSMA (S. A.). — La **reconstruction** des Chemin
fer néerlandais. (1 000 mots & fig.)

1947 **656 .234 (.494)**
ılletin des C.F.F., juin, p. 82.
FISCHER (W.). — Quelques indications sur la **réform**
s tarifs de voyageurs. (2 500 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1947 **385 .6**
ıll. des transp. intern. par. ch. de fer, avril, p. 149.
HOSTIE (J.). — L'évolution, dans les derniers 25 ans,
s **organisations internationales en matière de transport**
r fer. (12 000 mots.)

1947 **385 .63**
ıll. des transp. intern. par ch. de fer, mai, p. 192.
CHIMENTI (E.). — La **preuve du manquant** en cas
chargement effectué par l'expéditeur sans comptage
pesage de la part du chemin de fer. (3 500 mots.)

1947 **385 .63**
ıll. des transp. intern. par ch. de fer, mai, p. 197.
EGER (G.). — Les **dérogations à la C.I.M.**, prévues
les tarifs de réglementation, sont-elles compatibles
ec la C.I.M.? (4 500 mots.)

1947 **385. (09 (.438)**
ıll. des transp. intern. par ch. de fer, mai, p. 219.
La **reconstruction** des Chemins de fer de l'Etat polonais.
000 mots.)

Bulletin technique de la Suisse romande. (Lausanne.)

1947 **625 .144 .3**
ıll. technique de la Suisse romande, 10 mai, p. 125.
VUAGNAT (L.). — **Courbes de raccordement.** (2 000
ts, tableaux & fig.)

L'industrie des voies ferrées et des transports automobiles. (Paris.)

1947 **625 .43 (.44)**
ndustrie des Voies fer. et des Transp. automobiles,
janvier, p. 4.
ARTILLEUX (H.). — Le **téléphérique** de Serre-Che-
ıer. (3 000 mots & fig.)

1947 **621 .33**
L'industrie des Voies fer. et des Transp. automobiles, janvier, p. 8.
ERB (A.). — **Protection du matériel fixe** (sous-stations, voie) **et mobile** (locomotives, automotrices, tramways) **contre les courts-circuits.** (2 000 mots & fig.)

1947 **625 .258**
L'industrie des Voies fer. et des Transp. automobiles, février, p. 12.
ZOUCKERMANN. — Contribution du **frein électromagnétique** sur rail à la rénovation des tramways à l'étranger. (A suivre.) (3 000 mots & fig.)

1947 **621 .431 .72**
L'industrie des Voies fer. et des Transp. automobiles, février, p. 17.
HOULET. — Les applications ferroviaires des **transmissions électromagnétiques.** (1 500 mots & fig.)

1947 **625 .62 (.44)**
L'industrie des Voies fer. et des Transp. automobiles, mars, p. 26.
Les **Réseaux (de tramways)** d'Alsace et de Lorraine. (Strasbourg, Mulhouse, Metz et Colmar.) (8 000 mots & fig.)

1947 **621 .431 .72 (.44)**
L'industrie des Voies fer. et des Transp. automobiles, avril, p. 47.
TOURNEUR. — L'état actuel de la **traction Diesel** en France. (2 000 mots & fig.)

1947 **656 .136**
L'industrie des Voies fer. et des Transp. automobiles, avril, p. 53.
CASSAN. — Note sur le **graphitage des lignes aériennes trolleybus.** (2 000 mots & fig.)

La Technique moderne. (Paris.)

1946 **621 .165 & 621 .438**
La Technique moderne, nos 21 et 22, 1er et 15 novembre, p. 265; nos 23 et 24, 1er et 15 décembre, p. 300.
La **turbine à combustion** et la propulsion par réaction. (Application à la traction sur voie ferrée.) (4 000 mots & fig.)

1947 **698**
La Technique moderne, nos 1 et 2, 1er et 15 janvier, p. 1.
SAFFRE (E.). — Le pouvoir couvrant par opacité des **peintures.** Ses relations avec les consommations pratiques. (5 000 mots & fig.)

1947 **621 .31**
La Technique moderne, nos 7 et 8, 1er et 15 avril, p. 105.
LAURENT (P.). — Les **transmissions en courant continu à très haute tension.** (8 000 mots & fig.)

1947 **621 .43**
La Technique moderne, nos 7 et 8, 1er et 15 avril, p. 129.
ZELBSTEIN (U.). — **Mesures piézo-électriques.** (3 000 mots & fig.)

1947 **621 .9**
La Technique moderne, nos 9 et 10, 1er et 15 mai, p. 145.
PETRI (J.). — Les problèmes d'usinage dans la construction de **machines-outils.** (8 000 mots & fig.)

1947 **669 .1**
La Technique moderne, nos 9 et 10, 1er et 15 mai, p. 163.
Les **aciers au soufre.** (1 200 mots, tableaux & fig.)

1947 **669**
La Technique moderne, nos 9 et 10, 1er et 15 mai, p. 168.
SOURDILLON. — Le **traitement thermique des aciers et alliages divers.** Progrès récents. (6 000 mots & fig.)

Revue de l'Ecole polytechnique. (Bruxelles.)

1947 **691**
Revue de l'Ecole polytechnique, février, p. 25.
CAMERMAN (C.). — Quelques mots au sujet de la **protection du fer contre la corrosion.** (Suite et fin.) (1 200 mots & fig.)

1947 **0**
Revue de l'Ecole polytechnique, mars, p. 51.
CONTEMPRE (P.). — La **classification décimale.** Quelques notions sur son application. (2 500 mots.)

Revue générale des chemins de fer. (Paris.)

1947 **621 .335**
Revue générale des chemins de fer, février, p. 37.
HUG (Ad.-M.). — Le **comportement en marche des locomotives électriques à grande vitesse.** (3 500 mots & fig.)

1947 **624 .63 (.44)**
Revue générale des chemins de fer, février, p. 43.
OUDOTTE et DIDIER. — Destructions et reconstructions sur les Chemins de fer français (Suite) : **Viaduc** de Nogent-sur-Marne (sur la ligne de Paris à Bâle). (3 500 mots & fig.)

1947 **621 .133 .1**
Revue générale des chemins de fer, février, p. 51.
CHAN. — La **chauffe au mazout sur les locomotives à vapeur.** (3 200 mots & fig.)

1947 **621 .135. (01**
Revue générale des chemins de fer, février, p. 57.
LIENART et SONNEVILLE. — L'augmentation des **charges par essieu.** (3 000 mots, tableau et cartes.)

1947 **625 .23 (.**
Revue générale des chemins de fer, février, p. 64.
JANSSEN. — Le **parc de matériel à voyageurs** de S.N.C.F. de 1940 à 1946. (2 000 mots & tableaux.)

1947 **621 .87 (.**
Revue générale des chemins de fer, février, p. 70.
Nouvelle grue sur rail. (500 mots & fig.)

1947 **656. (06 (**
Revue générale des chemins de fer, mars, p. 73.
HONDELINK (E. R.). — La constitution et le r de l'**Office Central des Transports intérieurs europée** (4 000 mots.)

1947 **621 .431 .72 (.**
Revue générale des chemins de fer, mars, p. 77.
TOURNEUR. — Les **futurs autorails** de la S.N.C (4 000 mots, tableaux & fig.)

1947 **656 .235 .7 (.44) & 656 .237 (.**
Revue générale des chemins de fer, mars, p. 88.
HUTTER. — **Comptabilité et mode d'expédition envois de faible poids.** (6 000 mots & fig.)

1947 **656 .225 (.**
Revue générale des chemins de fer, mars, p. 100.
MAUREL. — **L'amélioration des relations « messa ries »** sur la S.N.C.F. depuis la libération. (2 500 m & tableau.)

In German.

Organ für die Fortschritte des Eisenbahnwese Glasers Annalen. (Berlin.)

1944 **625 .2**
Organ für die Fortschritte des Eisenbahnw. — Glas Annalen, Heft 3/4, Februar, S. 54.
SCHIEMANN (P.) — Zweiachsige hydraulisc **Zweiseitenkippwagen.** (1 200 Wörter & Abb.)

1944 **621**
Organ für die Fortschritte des Eisenbahnw. — Glas Annalen, Heft 5/6, März, S. 57.
ADOLPH (H.). — Verdrehbare Doppelkeilscheiben **Schraubenbeilagen.** Theorie und Anwendung. (5 000 W ter, 2 Tafeln & Abb.).

1944 **621 .133 (**
Organ für die Fortschritte des Eisenbahnw. — Glas Annales, Heft 5/6, März, S. 64.
MEINEKE (F.). — Der ideale **Lokomotivkessel.** (1 1 Wörter, 1 Tafel & Abb.)

1944 **621 .131**
Organ für die Fortschritte des Eisenbahnw. — Glas Annalen, Heft 5/6, März, S. 65.
METZELTIN. — Der **Ausnutzungsgrad der Lokom tive.** (4 000 Wörter.)

1944 **656 (.4)**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 5/6, März, S. 69.
ANDERS (E.). — Erkundliche Grundlagen des **Ver-hrs** in Europa und im grossdeutschen Raum. (11 000 örter & Abb.)

1944 **621 .131 .2**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 7/8, April, S. 85.
VORDERMAYER (K). — **Zweistoffantrieb für Loko-otiven.** (2 000 Wörter.)

1944 **625 .252**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 7/8, April, S. 87.
CLAUSEN. (O.). — Die richtige **Aufhängung des hsbremsgestänges** im Untergestell. (3 500 Wörter & bb.)

1944 **621 .33 (09**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 7/8, April, S. 94.
SCHULZE-MANITIUS (H.). — Entwicklung der **ektrischen Eisenbahnen.** (12 000 Wörter.)

1944 **656 .212 .4 & 656 .283**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 9/10, Mai, S. 111.
POTTHOFF (G.). — Zeichnerische Untersuchung des **sammenstosses von zwei Eisenbahnwagen.** (3 000 Wör-r & Abb.)

1944 **625 .216**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 9/10, Mai, S. 116.
POTTHOFF (G.). — **Veränderliche Zugkräfte** in senbahnzügen. (2 700 Wörter & Abb.)

1944 **621 .132 .8**
:gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 9/10, Mai, S. 121.
KALISCH (W.). — Der Energieverbrauch für die **mpfkondensation** auf schnell fahrenden Lokomotiven. 000 Wörter & Abb.)

1944 **621 .132 .8 (.47)**
gan für die Fortschritte des Eisenbahnw. — Glasers Annalen, Heft 9/10, Mai, S. 126.
LUBIMOFF (W.). — Versuchsergebnisse einer **Kon-nslokomotive** in Sowjetrussland. (4 000 Wörter & Abb.)

In English.

The Engineer. (London.)

1947 **621 .133 .1 (.41)**
Engineer, No. 4760, April 18, p. 331.
Oil fired locomotives on the G. N. R. (Ireland). (1 100 rds & fig.)

1947 **621 .133 .1 (.42) & 621 .138 (.42)**
Engineer, No. 4760, April 18, p. 341.
Coal weighing tenders on the L. M. S. (700 words & fig.)

1947 **625 .25 (.42)**
Engineer, No. 4762, May 2, p. 387.
Instrument for **testing vacuum brake systems.** (800 words & fig.)

1947 **621 .133 .1 (.42)**
Engineer, No. 4762, May 2, p. 388.
Oil storage depots on the G. W. R. (700 words & fig.)

1947 **62 (01**
Engineer, No. 4763, May 9, p. 398; No. 4764, May 16, p. 421.
TIMOSHENKO (S.). — **Stress concentration and fatigue failures.** (3 800 words & fig.)

1947 **621 .33 (.82)**
Engineer, No. 4764, May 16, p. 423.
Suburban **electrification on the Central Argentine Railway.** (1 300 words & fig.)

1947 **621 .333 (.42)**
Engineer, No. 4764, Mai 16, p. 430.
Lightweight traction motor. (1 200 words & fig.)

1947 **625 .232 (.42)**
Engineer, No. 4764, May 16, p .432.
Experimental **restaurant cars on the L. M. S.** (800 words & fig.)

1947 **621 .132 .7 (.54)**
Engineer, No. 4765, May 23, p. 447.
Heavy **shunting locomotives for port of Calcutta.** (1 400 words & fig.).

1947 **62. (01**
Engineer, No. 4765, May 23, p. 454.
Stress analysis by polarised light. (1 400 words & fig.)

1947 **62 (01**
Engineer, No. 4766, May 30, p. 468; No. 4767, June 6, p. 502.
OLIVER (D. A.) and HARRIS (G. T.). — **High creep strength austeninis gas turbine forgings.** (4 800 words & fig.)

1947 **625 .15 (.42)**
Engineer, No. 4766, May 30, p .477.
Restoration of L. P. T. B. viaduct at Kilburn. (1 200 words & fig.)

1947 **62 (01**
Engineer, No. 4767, June 6, p. 486.
WALKER (H.). — A **laboratory testing machine for helical gear tooth action.** (2 200 words & fig.)

Engineering. (London.)

1947 **669 & 691**
Engineering, No. 4235, March 28, p. 229.
THORNTON (B. M.). — Measurement of **corrosion** pits in **boiler tubes.** (1 800 words & fig.)

1947 **669**
Engineering, No. 4236, April 4, p. 273.
PARKER (R. T.), COX (G. M. L.) & TURNER (A. N.). — Sandcase **aluminium-magnesium alloys.** (5 000 words & fig.)

1947 **621 .133 .1**
Engineering. No. 4238, April 18, p. 303; No. 4242, May 16, p. 401.
FRY (L. H.). — **Heat balances for locomotive boilers.** (2 900 words & tables.)

1947 **621 .431 .72 (.45)**
Engineering, No. 4238, April 18, p. 320.
Italian **articulated Diesel railcar.** (500 words & fig.)

1947 **669**
Engineering, No. 4238, April 18, p. 322.
FORRESTER (P. G.) & GREENFIELD (L. T.). — **Adhesion of tin-base bearing alloys to steel.** (3 000 words & fig.)

1947 **625 .254 (.42)**
Engineering, No. 4239, April 25, p. 333.
Leak-tester for vacuum brakes, L. M. S. R. (800 words & fig.)

1947 **669**
Engineering, No. 4240, May 2, p. 369.
SINGER (A. R .E.) & JENNINGS (P. H.). — Hot-shortness of the aluminium-silicon alloys of commercial purity. (2 200 words & fig.)

The Locomotive. (London.)

1947 **621 .132 (.42)**
The Locomotive, No. 654, February 15, p. 15.
L. M. S. standard types. (500 words.)

1947 **621 .132 .4 (.42) & 621 .132 .6 (.42)**
The Locomotive, No. 654, February 15, p. 16.
New **L. M. S. locomotives** (concluded). (500 words & fig.)

1947 **621 .135 .2 (.42)**
The Locomotive, No. 654, February 15, p. 17.
Steel plate welded axlebox. (400 words & fig.)

1947 **621 .133 .3 (.71)**
The Locomotive, No. 654, February 15, p. 18.
Fusion welded boiler Canadian Pacific Railway. (1 200 words & fig.)

1947 **621 .132 .8 & 625 .616**
The Locomotive, No. 654, February 15, p. 20.
Some considerations regarding **locos. for Colonial Railways.** (1 500 words.)

1947 **621 .131 .3 & 656 .2**
The Locomotive, No. 654, February 15, p. 26; No. 6
May 15, p. 79.
OPIE (R.). — **Locomotive power, performance & r**
ing. (4 000 words & tables.)

1947 **621 .431 .72 (.4**
The Locomotive, No. 655, March 15, p. 31; No. 6
April 15, p. 61.
G. W. R. 2 500 h.p. **gaz turbine-electric locomoti**
(1 600 words.)

1947 **621 .133 .1 (.**
The Locomotive, No. 655, March 15, p. 36.
Conversion from **coal** to **oil burning.** (800 words & fi

1947 **621 .136 (.**
The Locomotive, No. 655, March 15, p. 49.
Coal weighing tenders L. M. S. Railway. (800 wo
& fig.).

1947 **621 .132 .1 (.**
The Locomotive, No. 655, March 15, p. 50.
STEAD (A.L.). — **French locomotive plans.** (1
words & fig.)

Mechanical Engineering. (New York.)

1947 **621 .**
Mechanical Engineering, February, p. 115.
KLEINSCHMIDT (R. V.). — Value of wet **compr**
sion in **gas-turbine** cycles. (1 200 words & fig.).

1947 **621 .133 .3 (.**
Mechanical Engineering, February, p. 166.
A. S. M. E. Boiler code. — Proposed **revisions and**
denda to boiler construction code. (1 500 words.)

1947 **621 .132 .1 (.73) & 621 .431 .72 (.**
Mechanical Engineering, March, p. 199.
Progress in railway mechanical engineering. (3
words & fig.)

1947 **621 .438 (.**
Mechanical Engineering, April, p. 273.
MEYER (A.). — Recent developments in gas turbin
(2 200 words & fig.)

1947 **621 .133 .3 (.**
Mechanical Engineering, April, p. 330.
A. S. M. E. boiler code. — Proposed revisions and
denda to boiler construction code. (900 words & tabl

1947 **621 .133 .3 (.**
Mechanical Engineering, May, p. 423.
A. S. M. E. boiler code. — Interpretations. (1
words.)

1947 **621 .438 (.73)**
Iechanical Engineering, June, p. 475.
HASKIN (J. R.). — The modern **gas turbine** in the ıdustrial power plant. (2000 words & fig.)

1947 **625 .2 (.73)**
Iechanical Engineering, June, p. 509.
Passenger car weight reduction. (600 words & table.)

Modern Transport. (London.)

1947 **385. (08 (.42)**
Iodern Transport, March 8, p. 4.
L. M. S. Ry. (Company meeting). (2 000 words.)

1947 **625 .232 (.42)**
Iodern Transport, March 8, p. 12.
New **L. M. S. corridor coaches.** (1 400 words & fig.)

1947 **625 .143 .4 (.42)**
Iodern Transport, March 8, p. 13.
Machine finished **rail joints** for London Transport nes. (400 words & fig.)

1947 **621 .335 (.42) & 621 .431 .72 (.42)**
Iodern Transport, March 8, p. 13.
Diesel-electric shunting locomotives. (400 words & fig.)

1947 **385. (08 (.42)**
Iodern Transport, March 8, p. 24.
G. W. R. (Company meeting). (2 200 words.)

1947 **385 (08 (.42)**
Iodern Transport, March 15, p. 4.
L. N. E. R. (Company meeting). (2 000 words.)

1947 **621 .132 .3 (.42)**
Iodern Transport, March 15, p. 9.
POULTNEY (E. C.). — The Atlantic type locomotive. 1 800 words & fig.)

1947 **621 .431 .72**
Iodern Transport, March 15, p. 19.
Swiss-built **gas-turbine locomotive.** (400 words & fig.)

1947 **625 .232 (.71)**
Iodern Transport, March 15, p. 19.
New **C. N. R. lounge cars.** (300 words & fig.)

1947 **385 (08 (.42)**
Iodern Transport, March 15, p. 22.
S. R. (Company Meeting). (2 400 words.)

1947 **625 .156 (.42)**
Iodern Transport, March 22, p. 6.
Concrete sliding stopblock. G. W. R. innovation. (150 ords & fig.)

1947 **625 .242 (.42)**
Iodern Transport, March 22, p. 9.
luminium alloy coal wagon. (250 words & fig.)

1947 **656 .222 (.42)**
Modern Transport, March 22, p. 17; April 19, p. 11.
RUDGARD (H.). — **Locomotive performance** and availability. (2 400 words.)

1947 **621 .431 .72 (.42)**
Modern Transport, March 29, p. 3.
L. M. S. develops **Diesel-electric traction.** (1 400 words & fig.)

1947 **625 .143 .1 (.42)**
Modern Transport, March 29, p. 6.
Flat bottom track on the L. N. E. R. (120 words & fig.)

1947 **656 .25**
Modern Transport, March 29, p. 6.
CASTLE (F. L.). — **Railway signalling** in the Dominions. (800 words.)

1947 **625 .232 (.42)**
Modern Transport, March 29, p. 11.
Rebuilding city service **railway cars.** Notable Liverpool overhead achievement. (300 words & fig.)

The Oil Engine. (London.)

1947 **621 .431 .72 (.42)**
The Oil Engine, April, p. 404.
Britain's first large **Diesel locomotives.** (500 words & fig.)

1947 **621 .431 .72 (.85)**
The Oil Engine, April, p. 405.
British railcars for Peru. (600 words & fig.)

1947 **62. (01**
The Oil Engine, April, p. 28; June, p. 44; July, p. 82.
HOLLIGAN (P. T.). — Modern **trends in bearing metals.** (3 200 words & fig.)

1947 **621 .438 (.42)**
The Oil Engine, June, p. 49.
The **closed-cycle gas turbine.** (2 600 words & fig.)

1947 **621 .132 .8 (.73) & 621 .438 (.73)**
The Oil Engine, July, p. 98.
Gas turbine locomotives using **pulverized coal.** (1 400 words & fig.)

Proceedings, American Society of Civil Engineers. (New York.)

1941 **62. (01 & 721 .3**
Proc. Americ. Soc. Civil Eng., No. 6, June, p. 961.
WITMER (F. P.) .— **Wind stress analysis** by the K-percentage method. (4 000 words, tables & fig.)

1941 **624 .2**
Proc. Americ. Soc. Civil Eng., No. 6, June, p. 1025.
GARRELTS (J. M.) & MADSEN (I. E.). — An investigation of **plate girder web splices.** (2 500 words & fig.)

1941 **627 .82 (.73)**
Proc. Americ. Soc. Civil Eng., No. 7, September, p. 1199.
BAUMANN (P.). — Design and construction of San Gabriel **Dam,** No. 1. (7 000 words, tables & fig.)

1941 **721 .1**
Proc. Americ. Soc. Civil Eng., No. 9, November, p. 1657.
MASTERS (F. M.). — **Timber friction pile foundations.** (4 000 words, tables & fig.)

1941 **624 .6 (.73)**
Proc. Americ. Soc. Civil Eng., No. 10, December, p. 1801.
GARRELTS (J. M.). — Design of St. Georges **tied arch span.** (2 500 words, tables & fig.)

1941 **656 (.73)**
Proc. Americ. Soc. Civil Eng., No. 10, December, p. 1827.
TEAL (J. E.). — **Development of transportation** in the United States. (8 000 words, tables & fig.)

1941 **624 .2**
Proc. Americ. Soc. Civil Eng., No. 10, December, p. 1851.
WINTER (G.). — **Lateral stability of unsymmetrical I. Beams and trusses** in bending. (3 000 words & fig.)

Railway Age. (New York.)

1947 **657**
Railway Age, February 8, p. 311.
BLAIR (J. F.). — The **ABC of depreciation accounting.** (3 000 words.)

1947 **621 .431 .72 (.73)**
Railway Age, February 8, p. 319.
1 500 Hp. **general purpose Diesel.** (1 800 words & fig.)

1947 **656 .225 (.73)**
Railway Age, February 15, p. 361.
ADAMS (B. T.). — The **I.C.'s stores operations mechanized.** (1 500 words & fig.)

1947 **621 .434 (.73)**
Railway Age, February 15, p. 363.
COUGHLAN (R. E.). — The Terminal **filtration of Diesel fuel.** (600 words & fig.).

1947 **621 .431 .72 (.73)**
Railway Age, February 15, p. 364.
Control for **Diesel-electric drive.** (400 words & fig.)

1947 **621 .133 .8 (.**
Railway Age, February 15, p. 365.
Sand trap for steam locomotives. (400 words & f

1947 **656 .254 (.**
Railway Age, February 15, p. 367.
More **C. T. C. on the Pere Marquette.** (1 800 wo & fig.)

1947 **625 .13 (.**
Railway Age, February 22, p. 412.
MORRISON (W. W.) & SEELEY (E. E.). — **Tur trouble** and how to correct it. (1 800 words & fig.)

1947 **625 .233 (.**
Railway Age, March 1, p. 456.
Power system for Pennsylvania cars. (1 200 wo & fig.)

1947 **625 .234 (.**
Railway Age, March 8, p. 498.
Electronic air conditioning control for railway pas ger cars. (1 500 words & fig.)

1947 **625 .232 (.**
Railway Age, March 15, p. 530.
CAMPBELL (E. D.). — **Trends** in railway **passen cars** design. (2 200 words & fig.)

1947 **625 .24 (.**
Railway Age, March 22, p. 592.
COX (A. T.). — Lighter and more durable **frei cars.** (600 words & fig.)

1947 **656 .254 (.**
Railway Age, March 22, p. 594.
Loud-speakers on Rio Grande. (1 000 words & fig.)

1947 **625 .(06 (.**
Railway Age, March 22, p .602.
A. R. E. A. — Convention section. — Many probl studied by engineering officers during busy Session Chicago. (8 600 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1947 **625 .143 .3 (.**
Railway Engineering and Maintenance, February, p. 1
McBRIAN (R.). — **Testing with magnaflux** on D. & R. G. W. (1 800 words & fig.)

1947 **625 .17 (.**
Railway Engineering and Maintenance, March, p. 2
WESTCOTT (G. R.). — What is an effective org zation for equipment maintenance. (2 400 words & fi

1947 **625 .14 (.73)**
Railway Engineering and Maintenance, April, p. 378.
SCOFIELD (J. R.). — **Asphalt ballast welded rails, good drainage** solve this station-track problem. (1 400 words & fig.)

1947 **656 .28 (.73)**
Railway Engineering and Maintenance, May, p. 493.
Fractures from wheel burns cause **derailment.** (600 words).

Railway Gazette. (London.)

1947 **621 .33 (.493)**
Railway Gazette, No. 8, March 7, p. 209.
New **Belgian electrification proposals** (400 words.)

1947 **621 .95 (.42)**
Railway Gazette, No. 8, March 7, p. 212.
A new horizontal boring machine. (1 400 words & fig.)

1947 **385. (08 (.42)**
Railway Gazette, No. 8, March 7, p. 218.
London Midland & Scottish Railway Company. — Annual general meeting. (8 000 words.)

1947 **621 .132 .3 (.91)**
Railway Gazette, No. 9, March 14, p. 243.
Forty new **three-cylinder locomotives** for the **Malayan Railway.** (900 words & fig.)

1947 **385 (08 (.42)**
Railway Gazette, No. 9, March 14, p. 250.
Great Western Railway Company. — Annual general meeting. (7 600 words.)

1947 **385 (08 (.42)**
Railway Gazette, No. 9, March 14, p. 253.
Southern Railway Company. — Annual general meeting. (9 800 words.)

1947 **385 (08 (.42)**
Railway Gazette, No. 9, March 14, p. 259.
London & North Eastern Railway Company. — Annual general meeting. (12 000 words.)

1947 **385 .4 (.42)**
Railway Gazette, No. 10, March 21, p. 279.
L. M. S. R. locomotive depots and motive power organisation. Linkage of work with the Chief Operating Manager and the Chief Mechanical Engineer. (1 400 words & fig.)

1947 **621 .132 .3 (.437)**
Railway Gazette, No. 10, March 21, p. 280.
New **express locomotives for Czechoslovakia.** First post-war design from the Skoda Works. (400 words & fig.)

1947 **385 (08 (.41)**
Railway Gazette, No. 10, March 21, p. 287.
Great Northern Railway Company (Ireland). — Annual general meeting. (1 400 words.)

1947 **621 .431 .72 (.42)**
Railway Gazette, No. 10, March 21, p. 302.
L. M. S. R. to experiment with main-line **Diesel-electric locomotives.** (1 500 words & fig.).

1947 **621 .33 (.42)**
Railway Gazette, No. 10, March 21, p. 303.
Notes on **the Brighton electrics** in 1946. (1 200 words & fig.)

1947 **621 .33 (.68)**
Railway Gazette, No. 10, March 21, p. 304.
Electrification in South Africa. (600 words & fig.)

Railway Mechanical Engineer. (New York.)

1947 **625 .244 (.73)**
Railway Mechanical Engineer, February, p. 53.
Santa Fe buys **stainless refrigerator car.** (1 500 words & fig.)

1947 **625 .253 (.73)**
Railway Mechanical Engineer, February, p. 60.
STEWART (C. D.). — **Air-brake control devices.** (4 000 words & fig.)

1947 **625 .27 (.73)**
Railway Mechanical Engineer, February, p. 73.
BRYANT (C. B.). — **Inspection railroad car parts.** (2 400 words.)

1947 **625 .232 (.73)**
Railway Mechanical Engineer, March, p. 109.
CAMPBELL (E. D.). — The **changing passenger car.** (2 400 words & fig.)

1947 **621 .431 .72 (.73)**
Railway Mechanical Engineer, March, p. 113.
Baldwin 1500 Hp. Diesel. (1 400 words & fig.)

1947 **621 .134 .5 (.73) & 625 .214 (.73)**
Railway Mechanical Engineer, March, p. 117.
CORRIGAN (B.). — Factors involved in **lubricating oil maintenance.** (2 400 words & tables.)

1947 **621 .135 .3 (.73) & 625 .213 (.73)**
Railway Mechanical Engineer, March, p. 120.
American steel foundries **coil-spring test machine.** (1 800 words & fig.)

1947 **625 .24 (.73)**
Railway Mechanical Engineer, March, p. 132.
REY (R. L.). — Construction of **welded freight cars.** (2 200 words & fig.)

In Spanish.

Ferrocarriles y Tranvias. (Madrid.)

1946 **62. (01 & 625 .212**
Ferrocarriles y Tranvias, diciembre, p. 617.
GUERRICABEITIA (José A.). — Ensayos de flexión para **detección de grietas en los ejes de vehiculos ferroviarios.** (2 600 palabras & fig.)

1946 **621 .132 .8 (.494) & 621 .438 (.494)**
Ferrocarriles y Tranvias, diciembre, p. 622.
MANUEL VILLAR. — **Nuevas locomotoras con turbina de gas.** (1 400 palabras).

1947 **625 .143 .4**
Ferrocarriles y Tranvias, marzo, p. 93.
ROMAN (C.). — Posibles mejoras en **juntas de carriles.** (3 000 palabras & fig.)

1947 **656 .256 .3**
Ferrocarriles y Tranvias, marzo, p. 97.
ELENSE (A. C.). — Sistemo de **block automatico** sin hilos de linea. (1 700 palabras & fig.)

1947 **621 .431 .72 (.469)**
Ferrocarriles y Tranvias, marzo, p. 104.
Plan de automotores de los Ferrocarriles portugueses. (2 500 palabras & fig.)

In Italian.

Giornale del Genio Civile (Roma).

1947 **721 .1**
Giornale del Genio Civile, gennaio, p. 5.
PENTA (F.). — Sulle formazioni lapidee come **terreni di fondazione.** (10 000 parole & fig.)

In Dutch.

Spoor- en Tramwegen. (Utrecht.)

1946 **621 .132**
Spoor- en Tramwegen, Nr 15, 25 April, p. 163.
NYMEYER (A. G.). — De oude en de nieuwe c wikkeling van de **stoomturbine-locomotief.** (4 500 wo den & fig.)

1946 **625 .112 (.**
Spoor- en Tramwegen, Nr 15, 25 April, p. 170.
LODEWYCKX (A.). — Eindelijk **één spoorwijdte** Australië? (1 000 woorden & 1 kaart.)

1946 **623 (.492) & 624 .32 (.49**
Spoor- en Tramwegen, Nr 16, 9 Mei, p. 182.
DE BRUINE (J.). — Twee phasen in de werkzaheden aan de **Moerdijkbrug.** (500 woorden & fig.)

1946 **621 .132 .3 (.49**
Spoor- en Tramwegen, Nr 16, 9 Mei, p. 184.
DE PATER (A. D.). — De nieuwe Zweedsche s **treinlocomotiven, serie 4000** der N. S. (1 400 woor & fig.)

1946 **621 .33 (.49**
Spoor- en Tramwegen, Nr 17, 23 Mei, p. 193.
VAN LESSEN (H. J.). — **Electrificatie** van het ba vak Amsterdam—Amersfoort. (700 woorden.)

1946 **621 .392 & 625 .2**
Spoor- en Tramwegen, Nr 18, 6 Juni, p. 205.
TABERNAL (W. F. H.). — Het **electrisch oplassch van wielflenzen.** (3 000 woorden & fig.)

1946 **621 .335 (.49**
Spoor- en Tramwegen, Nr 18, 6 Juni, p. 210.
De eerste na den oorlog in Zwitserland in dienst stelde **electrische locomotieven.** (700 woorden & fig.)

1946 **6**
Spoor- en Tramwegen, Nr 19, 20 Juni, p. 220.
REITSMA (S. A.). — **Verkeerswetenschap. — V keerseconomie. — Verkeerspolitiek.** (1 500 woorden.)

1946 **625 .1 (.492) & 656 .222 .1 (.49**
Spoor- en Tramwegen, Nr 19, 20 Juni, p. 222.
CUPERUS (J. L. A.). — **Baanverbeteringen** bij Nederlandsche Spoorwegen ten behoeve van het rijd met **groote treinsnelheden.** (1 800 woorden & fig.)

M. Weissenbruch & Co., Ltd., Printer to the King, 49, rue du Poinçon, Bruxelles.